

## Power Supply IC Series for TFT-LCD Panels

# Multi-Channel System Power Supply IC

## BM81028AMWV

### General Description

BM81028AMWV is a system power supply IC for TFT-LCD panels which are used in monitors, notebook type displays, and tablets.

This IC incorporates HAVDD, VCOM amplifier in addition to the power supply for panel driver (SOURCE, GATE, and LOGIC power supplies).

Moreover, this IC has a built-in EEPROM for sequence and output voltage setting retention.

### Applications

TFT-LCD Panels which are used in  
Monitors, Note PCs and Tablets.

### Features

- Input voltage range: 2.7V to 5.5V
- Standby current: 1.4 $\mu$ A (Typ)
- Operating temperature range: -40°C to +85°C
- Step-down DC/DC converter 2-channels (Synchronous rectification)
- Step-up DC/DC converter (Integrated load switch and Synchronous rectification)
- HAVDD amplifier (8bit Resolution)
- VCOM amplifier (8bit Resolution)
- Positive charge pump (Integrated diode)
- Negative charge pump
- I<sup>2</sup>C Interface Output Voltage Setting Control Function (Integrated EEPROM)
- Switching frequency switching function (600kHz, 1200kHz)
- Protection circuits
  - Under-Voltage Lockout
  - Thermal Shut Down
  - Over-Current Protection
  - Over-Voltage Protection
  - Short Circuit Protection (Timer Latch type)
- Input tolerant (SCL, SDA, EN)

### Package

UQFN28V4040A

W(Typ) D(Typ) H(Max)

4.0mm x 4.00mm x 1.00mm

### Typical Application Circuit

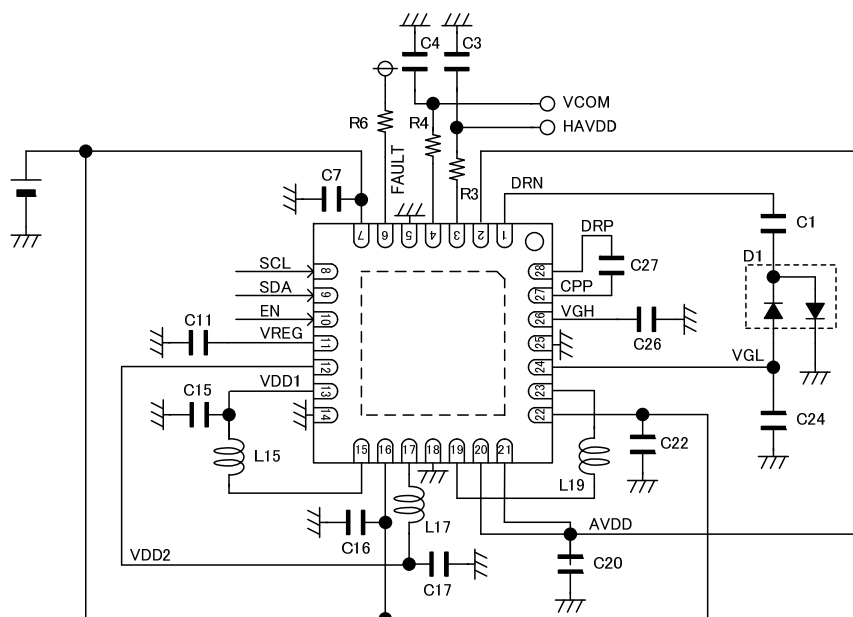


Fig.1. Typical Application Circuit

## ●Pin Configuration

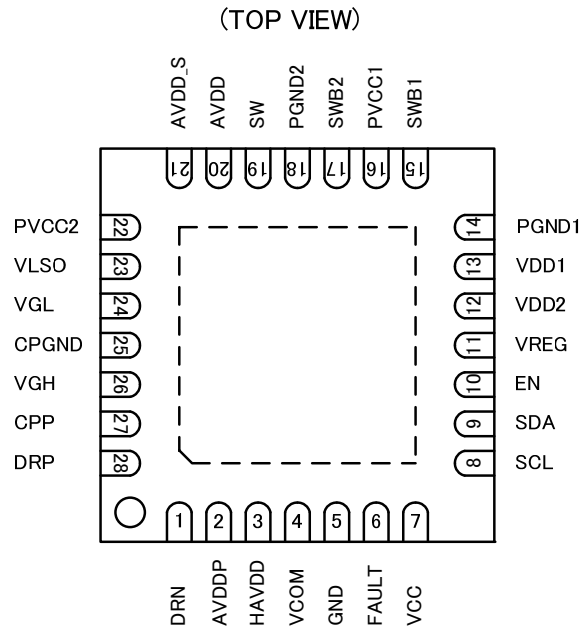


Fig.2 Pin Configuration

## ●Pin Descriptions

| Pin No. | Pin Name | Function                                | Pin No. | Pin Name | Function                                          |
|---------|----------|-----------------------------------------|---------|----------|---------------------------------------------------|
| 1       | DRN      | Negative charge pump driver pin         | 15      | SWB1     | Step-down DC/DC switching pin 1                   |
| 2       | AVDDP    | AVDD input                              | 16      | PVCC1    | Step-down DC/DC power supply input                |
| 3       | HAVDD    | HAVDD amplifier output                  | 17      | SWB2     | Step-down DC/DC switching pin 2                   |
| 4       | VCOM     | VCOM amplifier output                   | 18      | PGND2    | Step-down/-up DC/DC ground                        |
| 5       | GND      | Ground                                  | 19      | SW       | Step-up DC/DC switching pin                       |
| 6       | FAULT    | FAULT signal output                     | 20      | AVDD     | Step-up DC/DC output                              |
| 7       | VCC      | Power supply input                      | 21      | AVDD_S   | Step-up DC/DC output feedback                     |
| 8       | SCL      | Serial clock input (I2C)                | 22      | PVCC2    | Step-up DC/DC load switch input                   |
| 9       | SDA      | Serial clock data input (I2C)           | 23      | VLISO    | Step-up DC/DC load switch output                  |
| 10      | EN       | Enable input                            | 24      | VGL      | Negative charge pump feedback                     |
| 11      | VREG     | Inner power supply output               | 25      | CPGND    | Charge pump ground                                |
| 12      | VDD2     | Step-down DC/DC output feedback input 2 | 26      | VGH      | Positive charge pump feedback                     |
| 13      | VDD1     | Step-down DC/DC output feedback input 1 | 27      | CPP      | Built-in Positive charge pump switching Di output |
| 14      | PGND1    | Step-down DC/DC ground                  | 28      | DRP      | Positive charge pump driver pin                   |

## ●Block Diagram

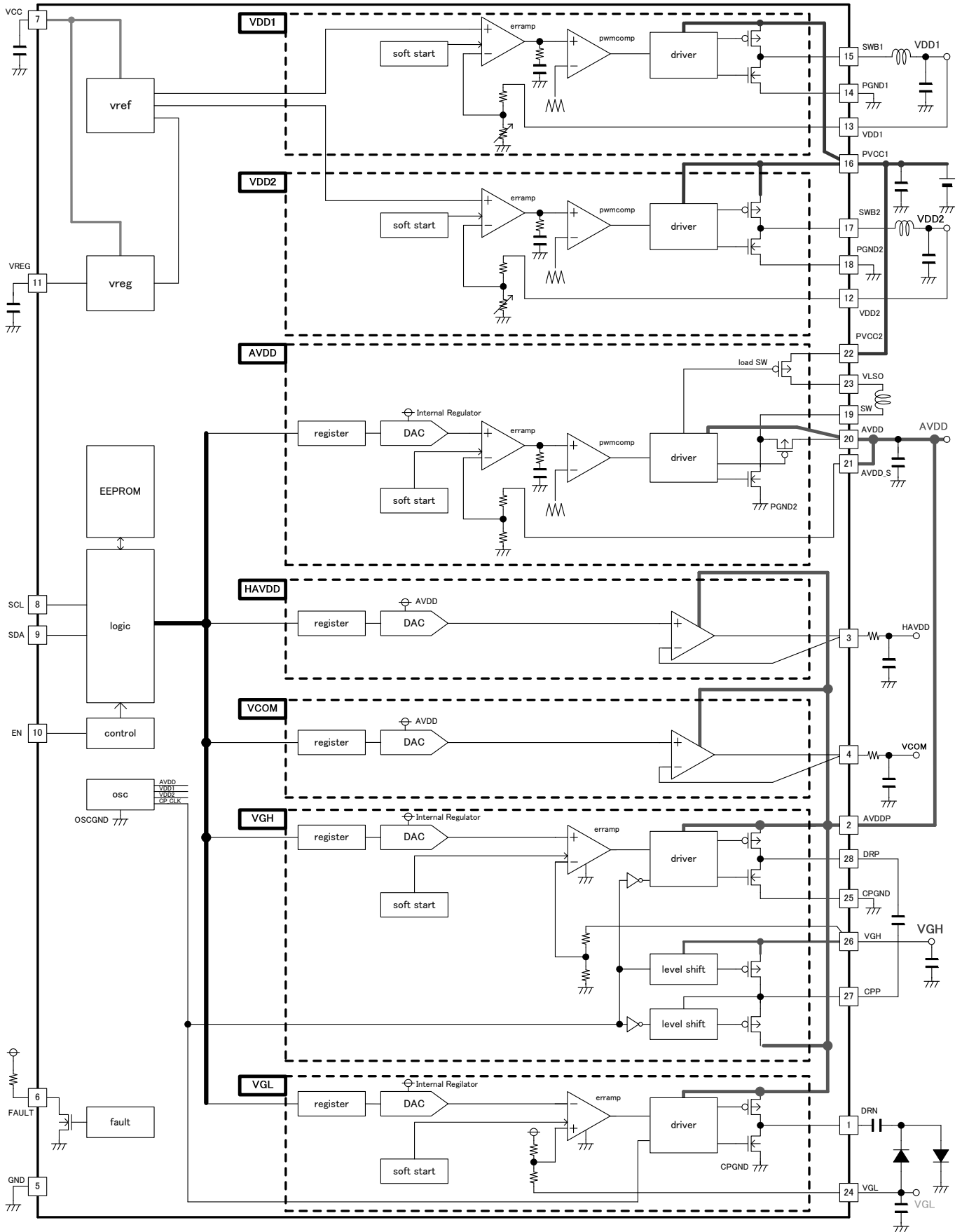


Fig.3 Block Diagram

## ●Function Description of Each Block

Enumerated below are the different blocks and the output voltages they generate. Also, discussed are the protection circuits that can shut down each block to prevent IC destruction.

All output voltages generated by each block, startup order, and delay time (DELAY1 and DELAY2) can be set through the EEPROM. Upon start-up, these settings are read from the EEPROM and copied to the registers.

### ① Buck Converter Block (VDD1, VDD2)

Generates the VDD1 and VDD2 voltages after VCC UVLO release at EN=High.

This block shuts down when SCP or OCP is detected.

### ② Boost Converter Block (AVDD)

Generates the AVDD voltage after the configured DELAY2 time.

This block shuts down when OVP, SCP, or OCP is detected.

### ③ HAVDD Amp Block (HAVDD)

Generates the HAVDD voltage based on the AVDD voltage.

Thus, the HAVDD voltage is produced after the AVDD voltage.

### ④ VCOM Amp Block (VCOM)

Generates the VCOM voltage based on the AVDD voltage.

Thus, the VCOM voltage is produced after the AVDD voltage.

### ⑤ Positive Charge Pump Block (VGH)

Generates the VGH voltage based on the AVDD voltage.

Thus, the VGH voltage is produced after the AVDD voltage.

This block shuts down when SCP is detected.

### ⑥ Negative Charge Pump Block (VGL)

Generates the VGL voltage based on the AVDD voltage.

It starts up after the configured DELAY2 time.

This block shuts down when SCP is detected.

# Absolute Maximum Ratings

| PARAMETER                    | SYMBOL               | LIMITS |     |           | Unit |
|------------------------------|----------------------|--------|-----|-----------|------|
|                              |                      | MIN    | TYP | MAX       |      |
| Power Supply Voltage         | VCC, PVCC1, PVCC2    | -0.3   | —   | 6.5       | V    |
| Output Pin                   | SWB1, SWB2           | -0.3   | —   | PVCC1+0.3 | V    |
|                              | VDD1, VDD2           | -0.3   | —   | 6.5       | V    |
|                              | AVDD, AVDDP, SW      | -0.3   | —   | 19        | V    |
|                              | VLSO                 | -0.3   | —   | 6.5       | V    |
|                              | HAVDD, VCOM          | -0.3   | —   | AVDDP+0.3 | V    |
|                              | DRP, DRN             | -0.3   | —   | AVDDP+0.3 | V    |
|                              | CPP                  | -0.3   | —   | 30        | V    |
|                              | VGH,                 | -0.3   | —   | 36        | V    |
|                              | VGL                  | -15    | —   | 0.3       | V    |
|                              | VREG                 | -0.3   | —   | VCC+0.3   | V    |
|                              | FAULT                | -0.3   | —   | 6.5       | V    |
| Functional Pin Voltage       | SCL, SDA, EN         | -0.3   | —   | 6.5       | V    |
| Maximum Junction temperature | Tjmax <sup>(1)</sup> | —      | —   | 150       | °C   |
| Power Dissipation            | Pd <sup>(2)</sup>    | 2.01   |     |           | W    |
| Operating Temperature Range  | Topr                 | -40    | —   | 85        | °C   |
| Storage Temperature Range    | Tstg                 | -55    | —   | 150       | °C   |

(1) Junction temperature at storage time.

(2) JEDEC standard (4 layers)

# Recommended Operating Ratings(T<sub>A</sub>=-40°C to +85°C)

| PARAMETER                                                                          | SYMBOL          | MIN  | TYP | MAX | Unit |
|------------------------------------------------------------------------------------|-----------------|------|-----|-----|------|
| Power Supply Voltage 1<br>( DC/DC Block Protection<br>Detection Voltage 1 setting) | VCC,PVCC1,PVCC2 | 2.7  | —   | 5.5 | V    |
| Power Supply Voltage 2<br>( DC/DC Block Protection<br>Detection Voltage 2 setting) |                 | 2.9  | —   | 5.5 | V    |
| Power Supply Voltage 3<br>( DC/DC Block Protection<br>Detection Voltage 3 setting) |                 | 3.1  | —   | 5.5 | V    |
| Power Supply Voltage 4<br>( DC/DC Block Protection<br>Detection Voltage 4 setting) |                 | 3.3  | —   | 5.5 | V    |
| SWB1,SWB2 Current                                                                  | ISW1            | —    | —   | 1.0 | A    |
| SW Current                                                                         | ISW2            | —    | —   | 1.5 | A    |
| Functional Pin Voltage                                                             | EN              | -0.1 | —   | 5.5 | V    |
| 2 Line Serial Pin Voltage                                                          | SDA, SCL        | -0.1 | —   | 5.5 | V    |
| 2 Line Serial Frequency                                                            | FCLK            | —    | —   | 400 | kHz  |

**●Electrical Characteristics (Unless otherwise specified, Ta=25°C, VCC, PVCC1, PVCC2=3.3V)**
**1. Buck DC/DC converter block 1 (VDD1)**

| PARAMETER                 | SYMBOL    | LIMITS |          |       | Unit | Condition                                     |
|---------------------------|-----------|--------|----------|-------|------|-----------------------------------------------|
|                           |           | MIN    | TYP      | MAX   |      |                                               |
| Output Voltage Range      | VDD1      | 1.7    | —        | 1.9   | V    | 50mV step                                     |
|                           |           | 2.4    | —        | 2.6   |      |                                               |
| Output Voltage Accuracy   | VDD1_R    | 1.782  | 1.8      | 1.818 | V    | VDD1=1.8V setting                             |
|                           |           | 2.475  | 2.5      | 2.525 | V    | VDD1=2.5V setting                             |
| Soft Start time           | VDD1_SS   | 0.5    | 1        | 2     | msec | The time where 90% of set voltage is reached. |
| Timer Latch Starting Time | VDD1_SCP  | —      | VDD1×0.8 | —     | V    |                                               |
| SWB1 H Side ON Resistance | RON_H1    | —      | 300      | 480   | mΩ   |                                               |
| SWB1 L Side ON Resistance | RON_L1    | —      | 300      | 480   | mΩ   |                                               |
| SWB1 H Side Leak Current  | IL_H1     | —      | 0        | 10    | μA   |                                               |
| SWB1 L Side Leak Current  | IL_L1     | —      | 0        | 10    | μA   |                                               |
| Current Limit             | ILMT_SWB1 | 1.0    | 1.5      | —     | A    |                                               |
| Discharge Resistance      | DISR_VDD1 | —      | 25       | 50    | Ω    |                                               |

**2. Buck DC/DC converter block 2 (VDD2)**

| PARAMETER                 | SYMBOL    | LIMITS |          |       | Unit | Condition                                     |
|---------------------------|-----------|--------|----------|-------|------|-----------------------------------------------|
|                           |           | MIN    | TYP      | MAX   |      |                                               |
| Output Voltage Range      | VDD2      | 1.1    | —        | 1.3   | V    | 50mV step                                     |
| Output Voltage Accuracy   | VDD2_R    | 1.188  | 1.2      | 1.212 | V    | VDD2=1.2V setting                             |
| Soft Start Time           | VDD2_SS   | 0.5    | 1        | 2     | msec | The time where 90% of set voltage is reached. |
| Timer Latch Starting Time | VDD2_SCP  | —      | VDD2×0.8 | —     | V    |                                               |
| SWB2 H Side On Resistance | RON_H2    | —      | 300      | 480   | mΩ   |                                               |
| SWB2 L Side On Resistance | RON_L2    | —      | 300      | 480   | mΩ   |                                               |
| SWB2 H Side Leak Current  | IL_H2     | —      | 0        | 10    | μA   |                                               |
| SWB2 L Side Leak Current  | IL_L2     | —      | 0        | 10    | μA   |                                               |
| Current Limit             | ILMT_SWB2 | 1.0    | 1.5      | —     | A    |                                               |
| Discharge Resistance      | DISR_VDD2 | —      | 25       | 50    | Ω    |                                               |

**3. Boost DC/DC converter block (AVDD)**

| PARAMETER                       | SYMBOL    | LIMITS |          |        | Unit | Condition                               |
|---------------------------------|-----------|--------|----------|--------|------|-----------------------------------------|
|                                 |           | MIN    | TYP      | MAX    |      |                                         |
| Output Voltage Range            | AVDD      | 8.0    | —        | 14.5   | V    | 0.1V step                               |
| Output Voltage Accuracy1        | AVDD_R1   | 10.395 | 10.5     | 10.605 | V    | AVDD=10.5V setting                      |
| Output Voltage Accuracy2        | AVDD_R2   | -1.0   | 0        | +1.0   | %    | AVDD=9.7 to 11.2V setting               |
| Output Voltage Accuracy3        | AVDD_R3   | -1.7   | 0        | +1.7   | %    | AVDD=8.0 to 9.6V, 11.3 to 12.8V setting |
| Output Voltage Accuracy4        | AVDD_R4   | -2.0   | 0        | +2.0   | %    | AVDD=12.9 to 14.5V setting              |
| Load Switch Soft Start time     | LS_SS     | 1      | 2        | 4      | msec |                                         |
| Soft Start Time                 | AVDD_SS   | 3.5    | 5        | 6.5    | msec | AVDD=10.5V setting                      |
| Timer Latch Starting Time       | AVDD_SCP  | —      | AVDD×0.8 | —      | V    |                                         |
| Over-Voltage Protection voltage | AVDD_OVP  | —      | 16       | —      | V    |                                         |
| SW H Side On Resistance         | RON_H3    | —      | 350      | 560    | mΩ   |                                         |
| SW L Side On Resistance         | RON_L3    | —      | 350      | 560    | mΩ   |                                         |
| SW H Side Leak Current          | IL_H3     | —      | 0        | 10     | μA   |                                         |
| SW L Side Leak Current          | IL_L3     | —      | 0        | 10     | μA   |                                         |
| Current Limit                   | ILMT_SW   | 1.5    | 2.0      | —      | A    |                                         |
| Load Switch ON Resistor         | RON_LS    | —      | 250      | 400    | mΩ   |                                         |
| Maximum Duty                    | DMAX      | 80     | 90       | —      | %    |                                         |
| Discharge Resistance            | DISR_AVDD | —      | 25       | 50     | Ω    |                                         |

**●Electrical Characteristics (Unless otherwise specified, Ta=25°C, VCC, PVCC1, PVCC2=3.3V)**
**4. HAVDD amplifier block (HAVDD)**

| PARAMETER                              | SYMBOL              | LIMITS                            |     |                          | Unit         | Condition              |
|----------------------------------------|---------------------|-----------------------------------|-----|--------------------------|--------------|------------------------|
|                                        |                     | MIN                               | TYP | MAX                      |              |                        |
| Output Voltage Range                   | HAVDD               | $0.6 \times \text{AVDD} - 3.1875$ | —   | $0.6 \times \text{AVDD}$ | V            | 12.5mV step            |
| Resolution                             | RES1                | —                                 | 8   | —                        | Bit          |                        |
| Integral Non-Linearity Error (INL)     | INL1                | -1                                | —   | +1                       | LSB          | Input code: 02h to FDh |
| Differential Non-Linearity Error (DNL) | DNL1                | -1                                | —   | +1                       | LSB          | Input code: 02h to FDh |
| Output Current Ability (Source)        | ISOURCE1            | —                                 | 200 | —                        | mA           |                        |
| Output Current Ability (Sink)          | ISINK1              | —                                 | 200 | —                        | mA           |                        |
| Load Stability                         | $\Delta \text{VO1}$ | —                                 | 10  | 70                       | mV           | Io=-15mA to +15mA      |
| Slew Rate                              | SR1                 | —                                 | 20  | —                        | V/ $\mu$ sec |                        |

**5. VCOM amplifier block (VCOM)**

| PARAMETER                              | SYMBOL    | LIMITS                             |     |                           | Unit         | Condition              |
|----------------------------------------|-----------|------------------------------------|-----|---------------------------|--------------|------------------------|
|                                        |           | MIN                                | TYP | MAX                       |              |                        |
| Output Voltage Range                   | VCOM      | $0.45 \times \text{AVDD} - 3.1875$ | —   | $0.45 \times \text{AVDD}$ | V            | 12.5mV step            |
| Resolution                             | RES2      | —                                  | 8   | —                         | Bit          |                        |
| Integral Non-Linearity Error (INL)     | INL2      | -1                                 | —   | +1                        | LSB          | Input code: 02h to FDh |
| Differential Non-Linearity Error (DNL) | DNL2      | -1                                 | —   | +1                        | LSB          | Input code: 02h to FDh |
| Output Current Ability (Source)        | VOL2      | —                                  | 200 | —                         | mA           |                        |
| Output Current Ability (Sink)          | ISOURCE2  | —                                  | 200 | —                         | mA           |                        |
| Load Stability                         | ISINK2    | —                                  | 10  | 70                        | mV           | Io=-15mA to +15mA      |
| Slew Rate                              | SR2       | —                                  | 20  | —                         | V/ $\mu$ sec |                        |
| Discharge Resistor                     | DISR_VCOM | —                                  | 50  | 100                       | $\Omega$     |                        |

**6. Positive charge pump block (VGH)**

| PARAMETER                 | SYMBOL   | LIMITS |                         |      | Unit     | Condition       |
|---------------------------|----------|--------|-------------------------|------|----------|-----------------|
|                           |          | MIN    | TYP                     | MAX  |          |                 |
| Output Voltage Range      | VGH      | 13     | —                       | 26   | V        | 0.2V step       |
| Output Voltage Accuracy   | VGH_R    | 17.1   | 18                      | 18.9 | V        | VGH=18V setting |
| Soft Start time           | VGH_SS   | 3.5    | 5                       | 6.5  | msec     | VGH=18V setting |
| Timer Latch Starting Time | VGH_SCP  | —      | $\text{VGH} \times 0.8$ | —    | V        |                 |
| DRP H Side On Resistance  | RON_H4   | —      | 5                       | —    | $\Omega$ |                 |
| DRP L Side On Resistance  | RON_L4   | —      | 10                      | —    | $\Omega$ |                 |
| CPP H Side On Resistance  | RON_H4   | —      | 10                      | —    | $\Omega$ |                 |
| CPP L Side On Resistance  | RON_L4   | —      | 10                      | —    | $\Omega$ |                 |
| Discharge Resistance      | DISR_VGH | —      | 150                     | 300  | $\Omega$ |                 |

**7. Negative charge pump block (VGL)**

| PARAMETER                 | SYMBOL   | LIMITS |                         |      | Unit     | Condition         |
|---------------------------|----------|--------|-------------------------|------|----------|-------------------|
|                           |          | MIN    | TYP                     | MAX  |          |                   |
| Output Voltage Range      | VGL      | -9.5   | —                       | -4   | V        | 0.1V step         |
| Output Voltage Accuracy   | VGL_R    | -6.3   | -6                      | -5.7 | V        | VGH=-6.0V setting |
| Soft Start time           | VGL_SS   | 3.5    | 5                       | 6.5  | msec     |                   |
| Timer Latch Starting Time | VGL_SCP  | —      | $\text{VGL} \times 0.8$ | —    | V        |                   |
| DRN H Side On Resistance  | RON_H5   | —      | 5                       | —    | $\Omega$ |                   |
| DRN L Side On Resistance  | RON_L5   | —      | 10                      | —    | $\Omega$ |                   |
| Discharge Resistance      | DISR_VGL | —      | 250                     | 500  | $\Omega$ |                   |

**●Electrical Characteristics (Unless otherwise specified, Ta=25°C, VCC, PVCC1, PVCC2=3.3V)**
**8. Overall (Entire device)**

Overall (Entire device)

| PARAMETER                                         | SYMBOL     | LIMITS |      |      | Unit | Condition                               |
|---------------------------------------------------|------------|--------|------|------|------|-----------------------------------------|
|                                                   |            | MIN    | TYP  | MAX  |      |                                         |
| 【Inside Regulator Voltage】                        |            |        |      |      |      |                                         |
| VREG Output Voltage                               | VREG       | 2.15   | 2.3  | 2.45 | V    |                                         |
| Load Stability                                    | $\Delta V$ | —      | 20   | 100  | mV   | IVREG=20mA                              |
| 【Oscillator Block】                                |            |        |      |      |      |                                         |
| DC/DC Block Oscillating Frequency 1               | FOSC1      | 480    | 600  | 720  | KHz  |                                         |
| DC/DC Block Oscillating Frequency 2               | FOSC2      | 960    | 1200 | 1440 | KHz  |                                         |
| Charge Pump block Oscillating Frequency 1         | FOSC1_CP   | 240    | 300  | 360  | KHz  |                                         |
| Charge Pump block Oscillating Frequency 2         | FOSC2_CP   | 480    | 600  | 720  | KHz  |                                         |
| 【Under Voltage Lock Out (UVLO) Circuit】           |            |        |      |      |      |                                         |
| UVLO return voltage                               | VUVLO      | 2.2    | 2.4  | 2.6  | V    |                                         |
| UVLO detection voltage                            | VDET       | 1.9    | 2.1  | 2.3  | V    |                                         |
| Hysteresis                                        | VHYS       | -      | 0.3  | -    | V    |                                         |
| 【DC/DC Block Under-Voltage Lockout Circuit Block】 |            |        |      |      |      |                                         |
| DC/DC Block Protection Detection Voltage 1        | DC_DET1    | 2.35   | 2.5  | 2.65 | V    | UVLO is released when VCC exceeds 2.8V. |
| DC/DC Block Protection Detection Voltage 2        | DC_DET2    | 2.55   | 2.7  | 2.85 | V    | UVLO is released when VCC exceeds 3.0V. |
| DC/DC Block Protection Detection Voltage 3        | DC_DET3    | 2.75   | 2.9  | 3.05 | V    | UVLO is released when VCC exceeds 3.2V. |
| DC/DC Block Protection Detection Voltage 4        | DC_DET4    | 2.95   | 3.1  | 3.25 | V    | UVLO is released when VCC exceeds 3.4V. |
| DC/DC Block Protection Return Voltage 1           | DC_REL1    | 2.55   | 2.7  | 2.85 | V    |                                         |
| DC/DC Block Protection Return Voltage 2           | DC_REL2    | 2.75   | 2.9  | 3.05 | V    |                                         |
| DC/DC Block Protection Return Voltage 3           | DC_REL3    | 2.95   | 3.1  | 3.25 | V    |                                         |
| DC/DC Block Protection Return Voltage 4           | DC_REL4    | 3.15   | 3.3  | 3.45 | V    |                                         |
| 【FAULT Signal Output Block】                       |            |        |      |      |      |                                         |
| Output Off Leak Current                           | IFL        | —      | 0    | 10   | uA   |                                         |
| Output On Resistance                              | RON_F      | —      | 1    | 2    | kΩ   |                                         |
| 【Control Signal Block1 SDA, SCL】                  |            |        |      |      |      |                                         |
| Minimum Output Voltage                            | VSDA       | —      | —    | 0.4  | V    | ISDA=3mA                                |
| H Level Input Voltage                             | VIH1       | 1.7    | —    | —    | V    | VCC=2.5~5.5V<br>Ta=-40~+85°C            |
| L Level Input Voltage                             | VIL1       | —      | —    | 0.6  | V    | VCC=2.5~5.5V<br>Ta=-40~+85°C            |
| 【Control Signal Block2 EN】                        |            |        |      |      |      |                                         |
| Pull-Down Resistance Value                        | RCTL2      | 280    | 400  | 520  | kΩ   |                                         |
| H Level Input Voltage                             | VIH2       | 1.7    | —    | —    | V    | VCC=2.5~5.5V<br>Ta=-40~+85°C            |
| L Level Input Voltage                             | VIL2       | —      | —    | 0.6  | V    | VCC=2.5~5.5V<br>Ta=-40~+85°C            |
| 【Overall】                                         |            |        |      |      |      |                                         |
| Standby Consumption Current                       | ICC1       | 0.8    | 1.4  | 2.0  | μA   | EN=L                                    |
| Consumption Current                               | ICC2       | 1.7    | 3.2  | 4.7  | mA   | EN=H, No switching                      |



●Reference Data  
(Unless otherwise specified, Ta=25°C, VCC, PVCC1, PVCC2=3.3V, VDD1=2.5V, VDD2=1.2V, AVDD=10.5V, VGH=18V, VGL=-6V, HAVDD=5.25V, VCOM=3.25V, no load)

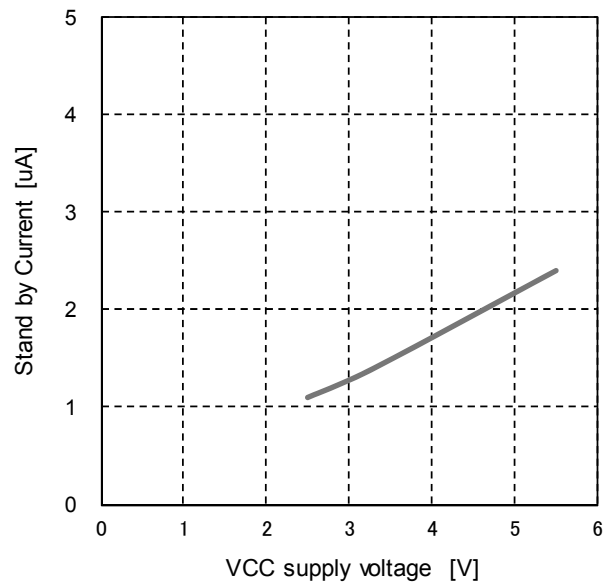


Fig.4 Standby Current

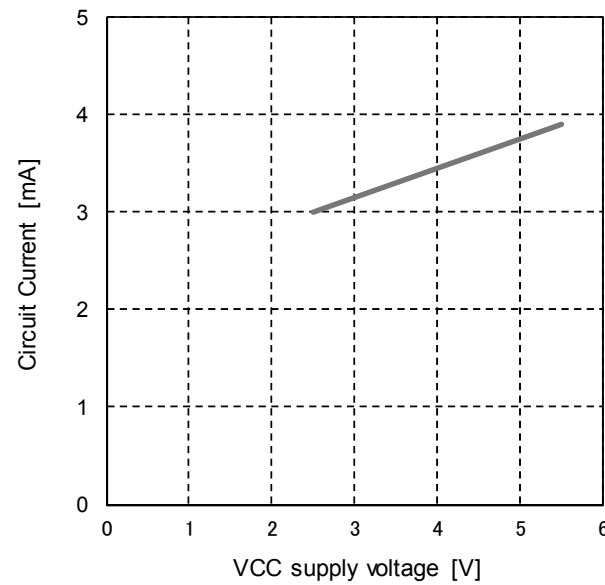


Fig.5 Circuit Current (No switching)

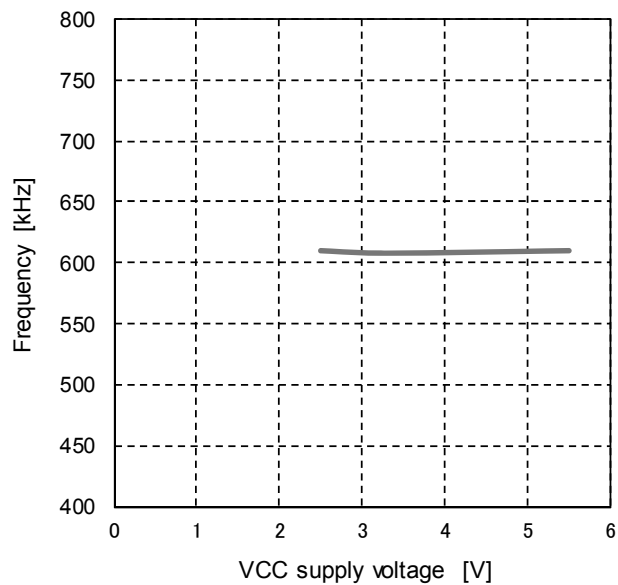


Fig.6 Switching Frequency (600kHz)

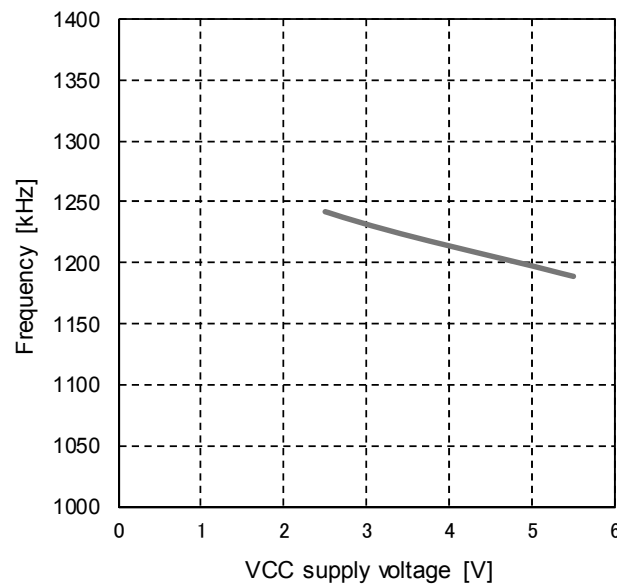


Fig.7 Switching Frequency (1200kHz)

●Reference Data  
(Unless otherwise specified, Ta=25°C, VCC, PVCC1, PVCC2=3.3V, VDD1=2.5V, VDD2=1.2V, AVDD=10.5V, VGH=18V, VGL=-6V, HAVDD=5.25V, VCOM=3.25V, no load)

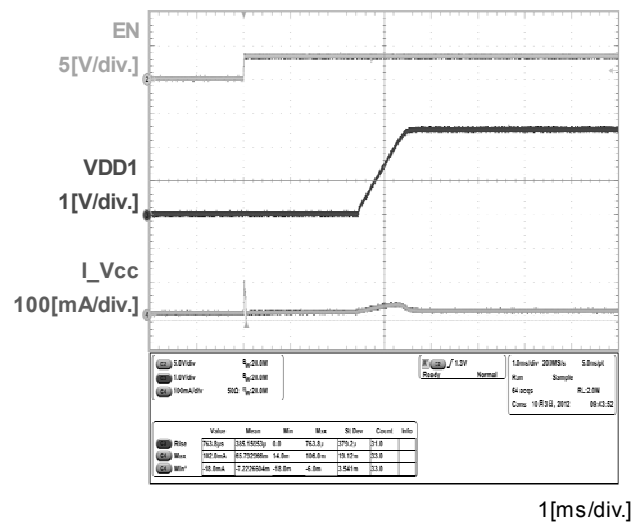


Fig.8 VDD1Start-up Sequence

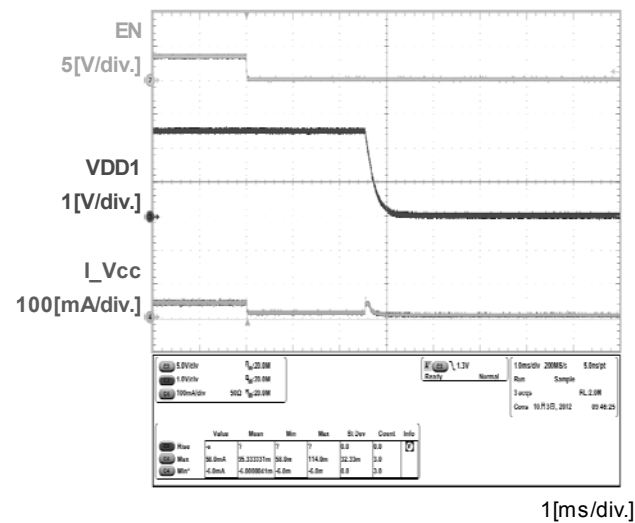


Fig.9 VDD1 Off Sequence

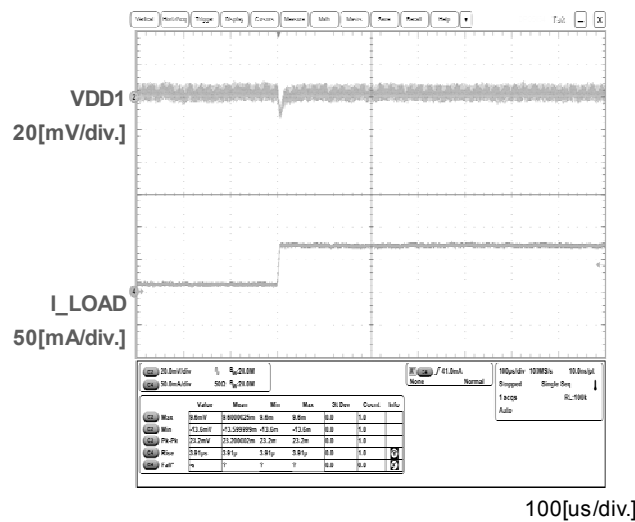


Fig.10 VDD1Load Transient  
(25mA→75mA,tr=4us)

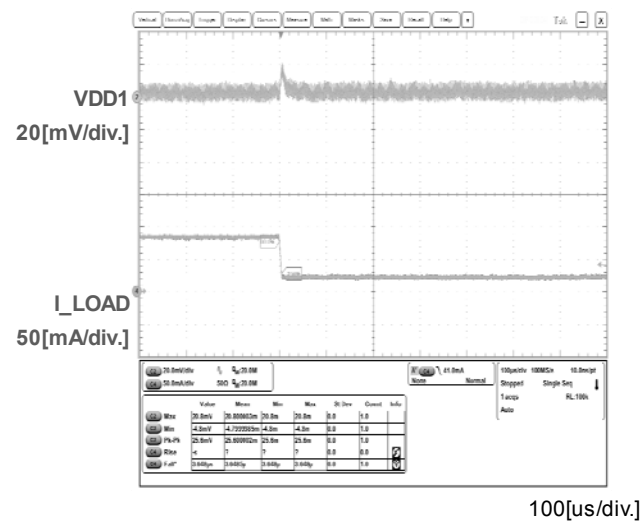


Fig.11 VDD1Load Transeint  
(75mA→25mA,tf=4us)

●Reference  
(Unless otherwise specified, Ta=25°C, VCC, PVCC1, PVCC2=3.3V, VDD1=2.5V, VDD2=1.2V, AVDD=10.5V, VGH=18V, VGL=-6V, HAVDD=5.25V, VCOM=3.25V, no load)

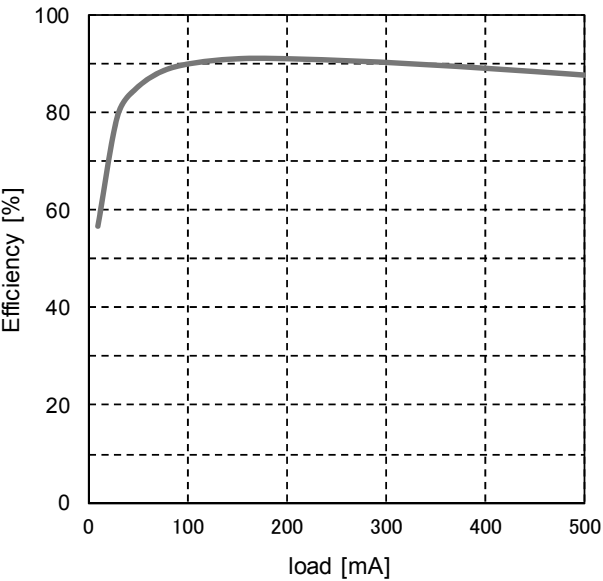


Fig.12 VDD1 Efficiency

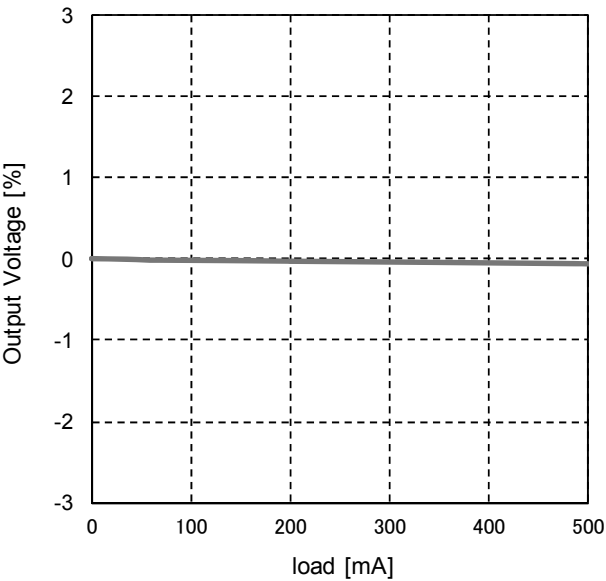


Fig.13 VDD1Load Regulation

●Reference Data  
(Unless otherwise specified, Ta=25°C, VCC, PVCC1, PVCC2=3.3V, VDD1=2.5V, VDD2=1.2V, AVDD=10.5V, VGH=18V, VGL=-6V, HAVDD=5.25V, VCOM=3.25V, no load)

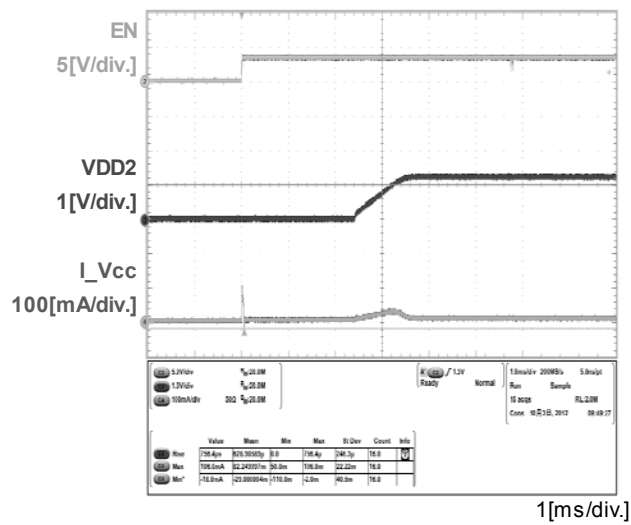


Fig.14 VDD2 Start-up Sequence

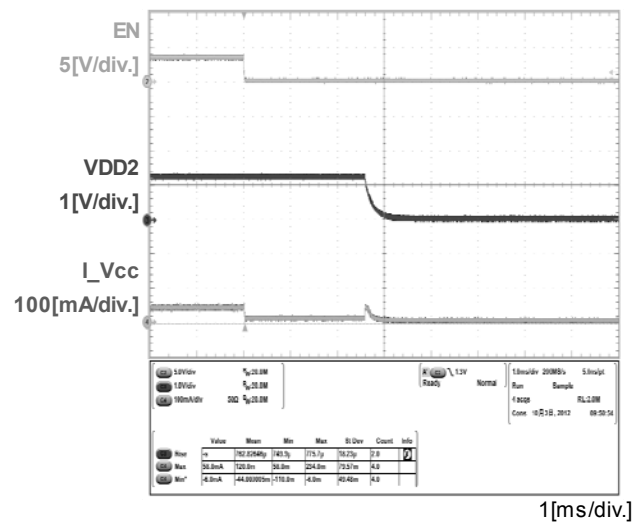


Fig.15 VDD2 Off Sequence

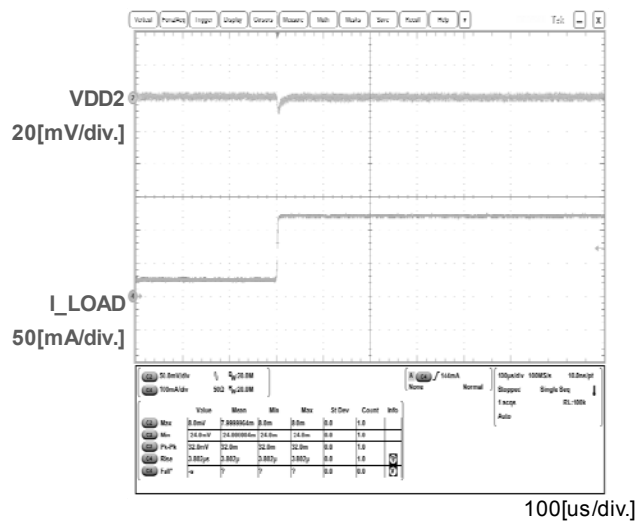


Fig.16 VDD2 Load Transient  
(50mA→250mA, tr=4us)

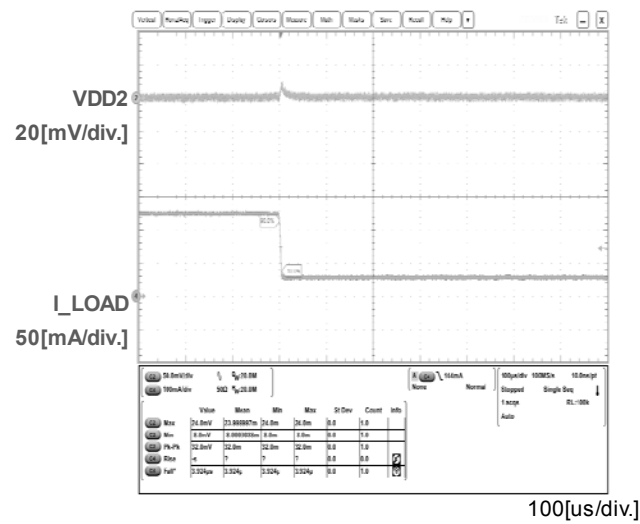


Fig.17 VDD2 Load Transient  
(250mA→50mA, tr=4us)

●Reference Data  
(Unless otherwise specified, Ta=25°C, VCC, PVCC1, PVCC2=3.3V, VDD1=2.5V, VDD2=1.2V, AVDD=10.5V, VGH=18V, VGL=-6V, HAVDD=5.25V, VCOM=3.25V, no load)

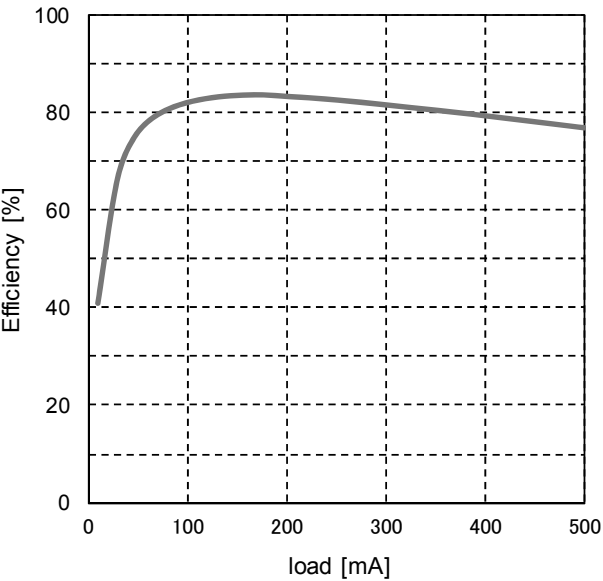


Fig.18 VDD2 Efficiency

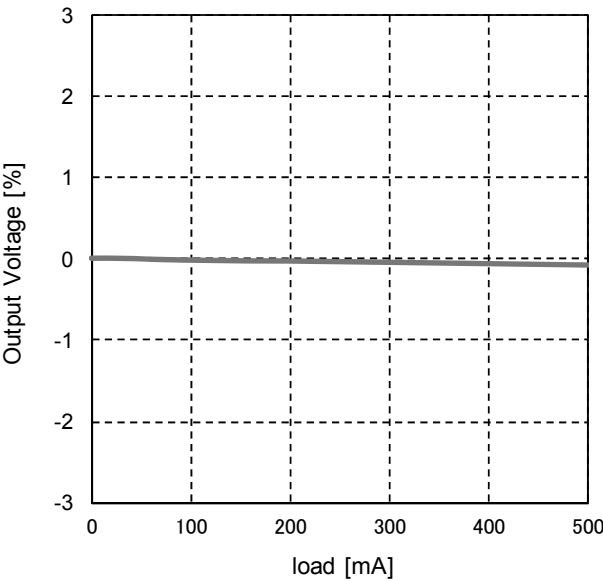


Fig.19 VDD2 Load Regulation

●Reference Data  
(Unless otherwise specified, Ta=25°C, VCC, PVCC1, PVCC2=3.3V, VDD1=2.5V, VDD2=1.2V, AVDD=10.5V, VGH=18V, VGL=-6V, HAVDD=5.25V, VCOM=3.25V, no load)

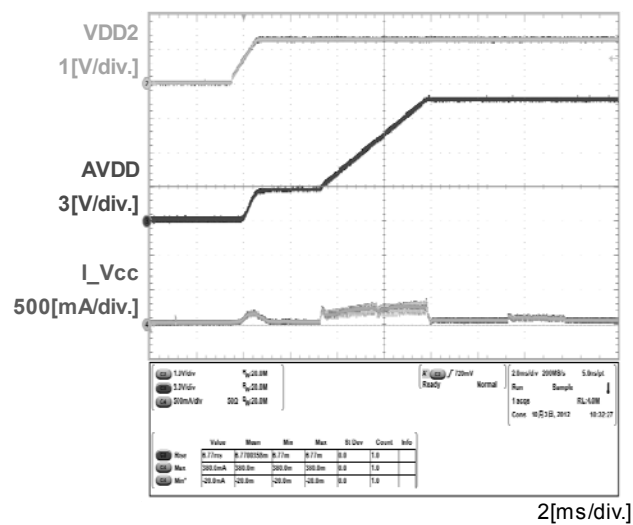


Fig.20 AVDD Start-up Sequence

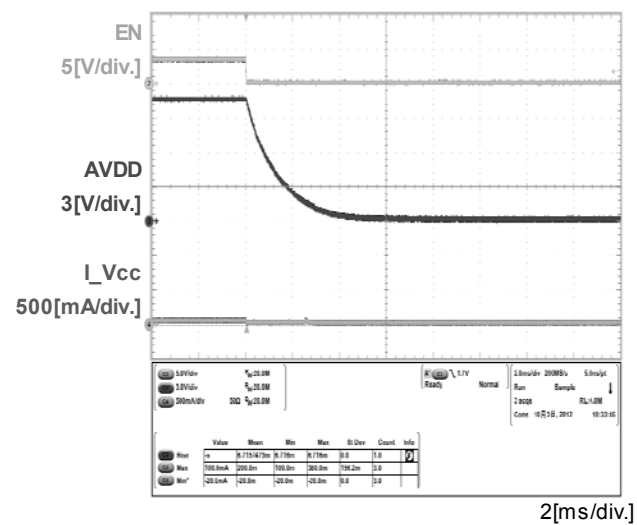


Fig.21 AVDD Off Sequence

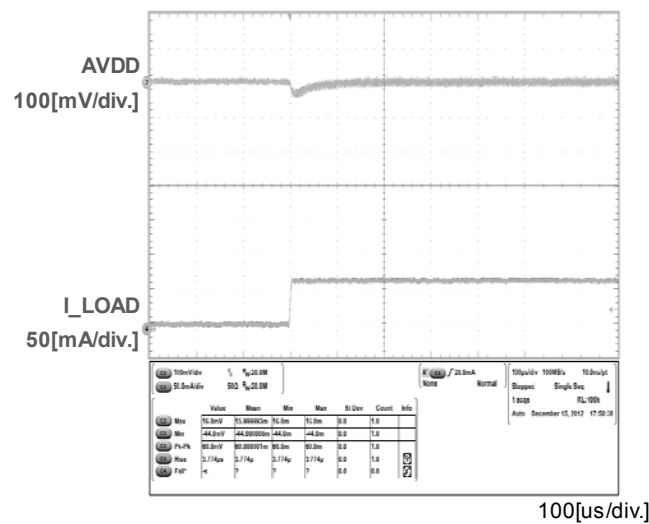


Fig.22 AVDD Load Transient  
(10mA→70mA, tr=4us)

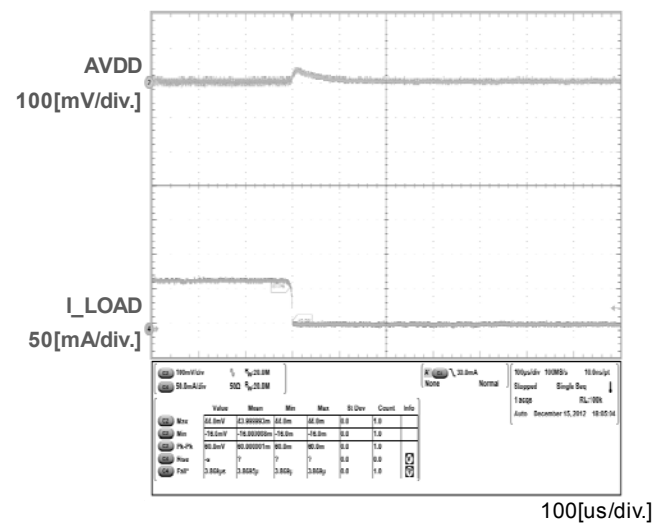


Fig.23 AVDD Load Transient  
(70mA→10mA, tf=4us)

●Reference Data  
(Unless otherwise specified, Ta=25°C, VCC, PVCC1, PVCC2=3.3V, VDD1=2.5V, VDD2=1.2V, AVDD=10.5V, VGH=18V, VGL=-6V, HAVDD=5.25V, VCOM=3.25V, no load)

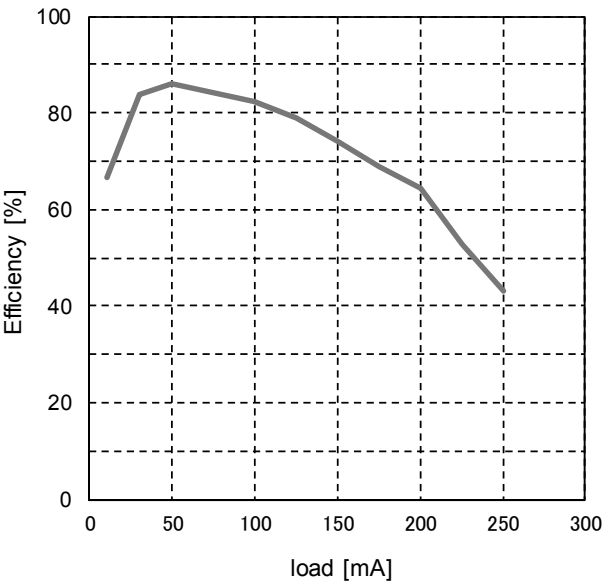


Fig.24 AVDD Efficiency

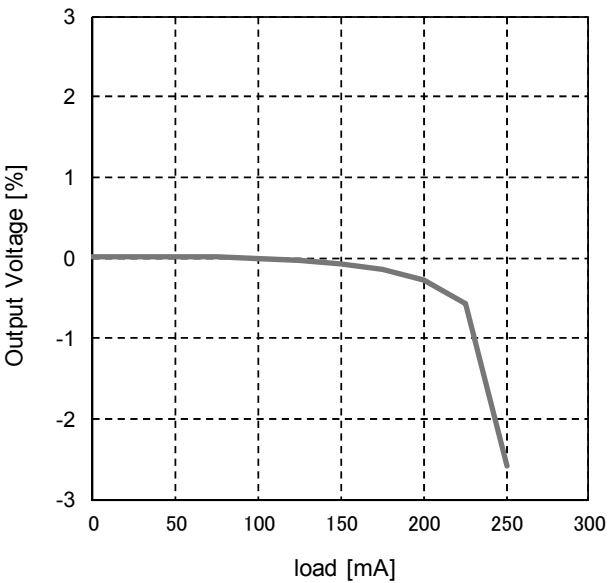


Fig.25 AVDD Load Regulation

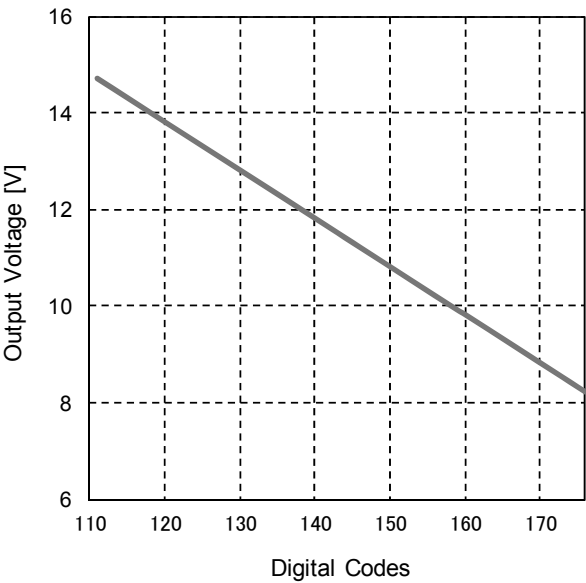


Fig.26 AVDD Linearity

●Reference Data  
(Unless otherwise specified, Ta=25°C, VCC, PVCC1, PVCC2=3.3V, VDD1=2.5V, VDD2=1.2V, AVDD=10.5V, VGH=18V, VGL=-6V, HAVDD=5.25V, VCOM=3.25V, no load)

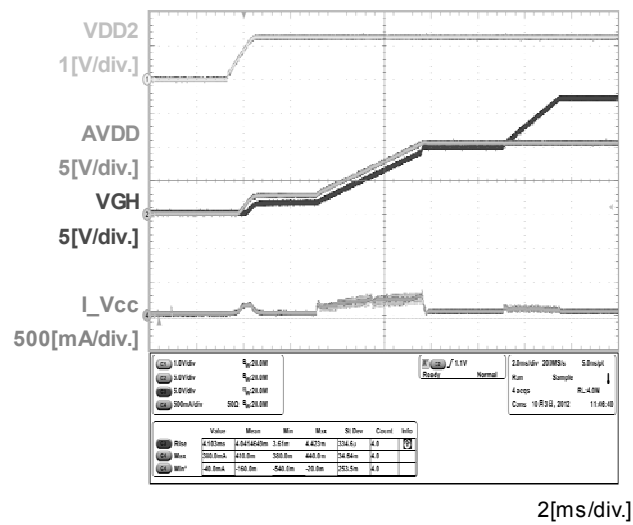


Fig.27 VGH Start-up Sequence

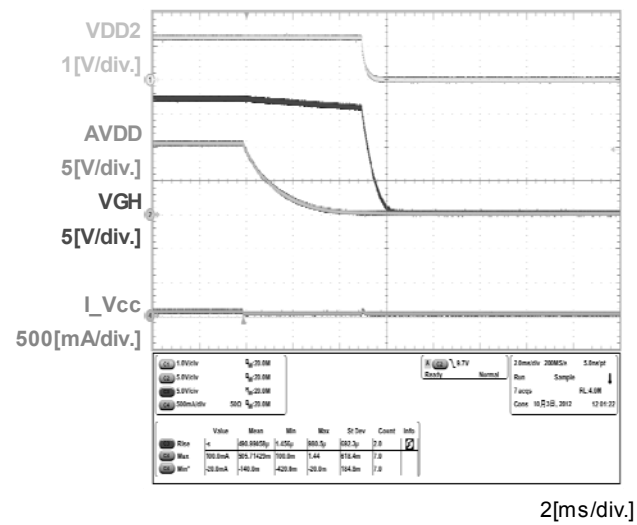
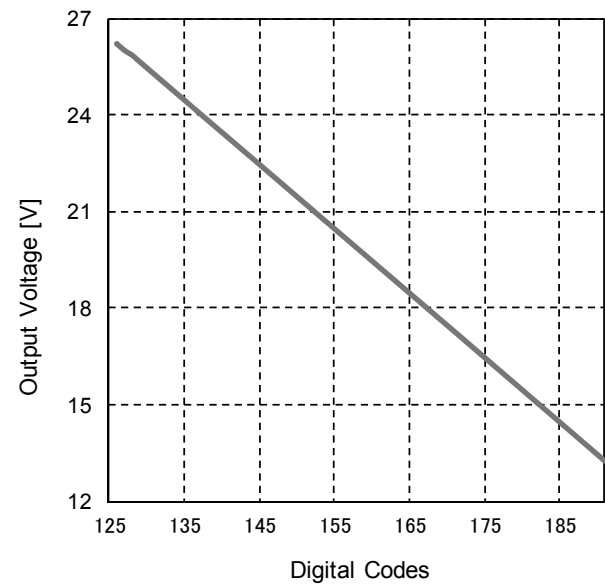
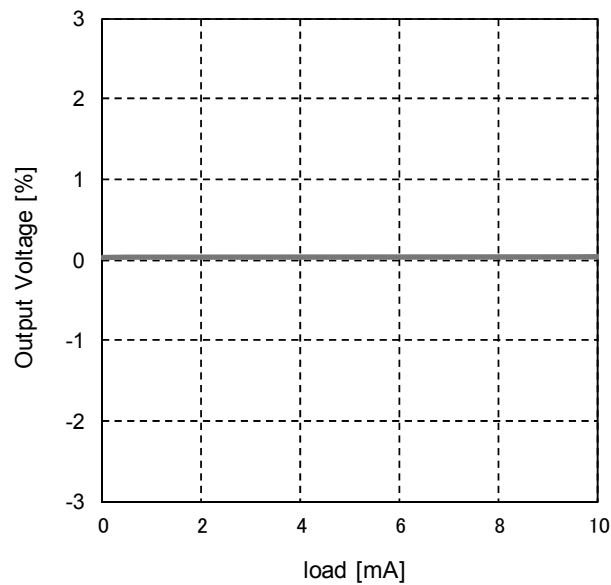


Fig.28 VGH Off Sequence





●Reference Data  
(Unless otherwise specified, Ta=25°C, VCC, PVCC1, PVCC2=3.3V, VDD1=2.5V, VDD2=1.2V, AVDD=10.5V, VGH=18V, VGL=-6V, HAVDD=5.25V, VCOM=3.25V, no load)

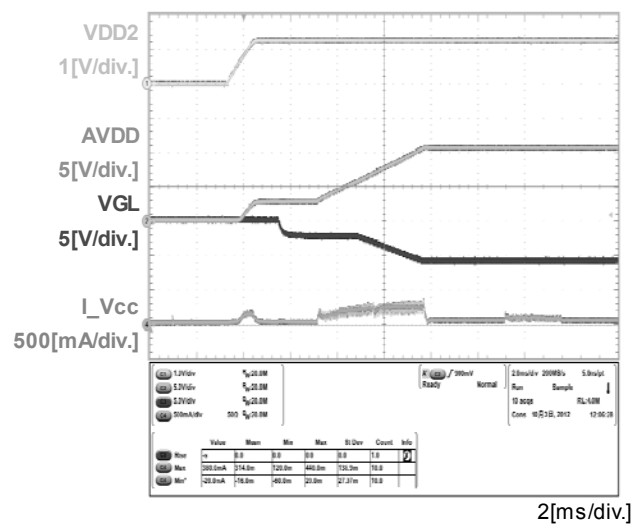


Fig.31 VGL Start-up Sequence

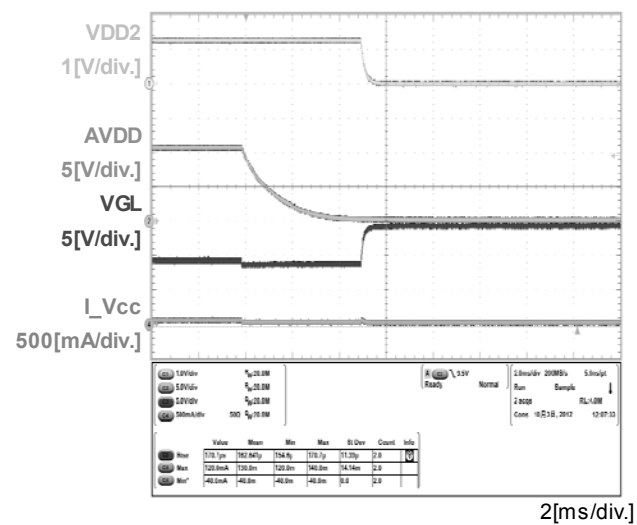


Fig.32 VGL Off Sequence

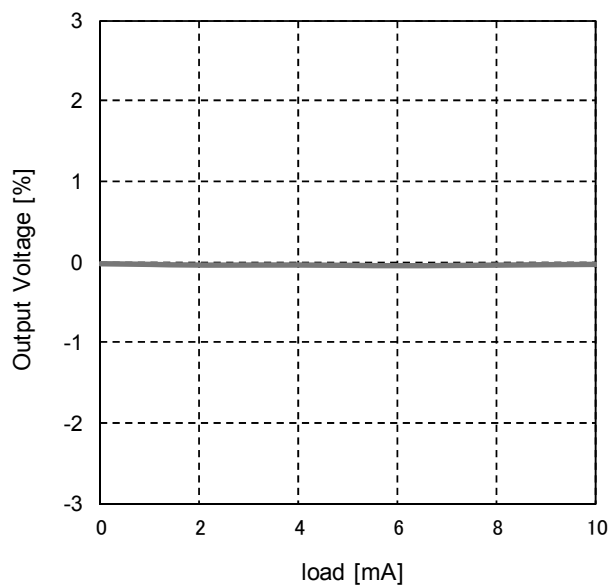


Fig.33 VGL Load Regulation

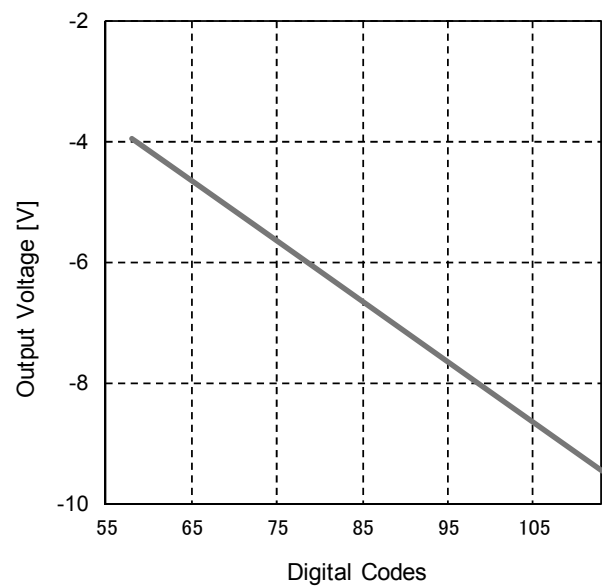


Fig.34 VGL Linearity

●Reference Data  
(Unless otherwise specified, Ta=25°C, VCC, PVCC1, PVCC2=3.3V, VDD1=2.5V, VDD2=1.2V, AVDD=10.5V, VGH=18V, VGL=-6V, HAVDD=5.25V, VCOM=3.25V, no load)

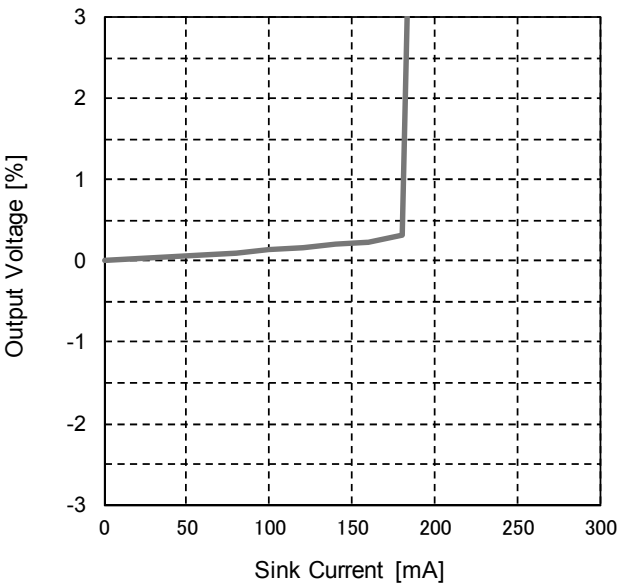


Fig.35 HAVDD Sink Current

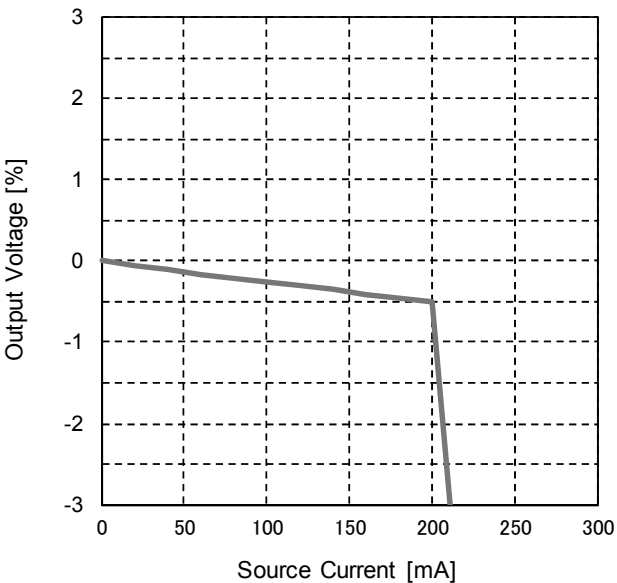
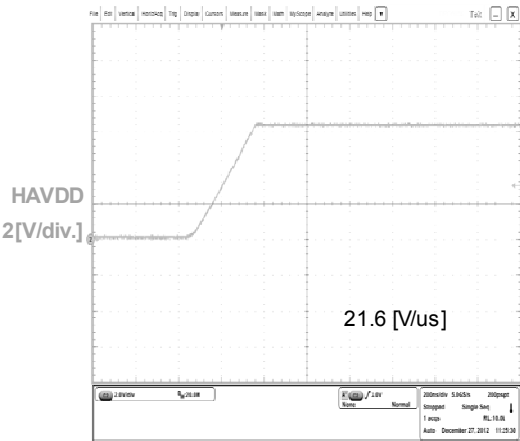
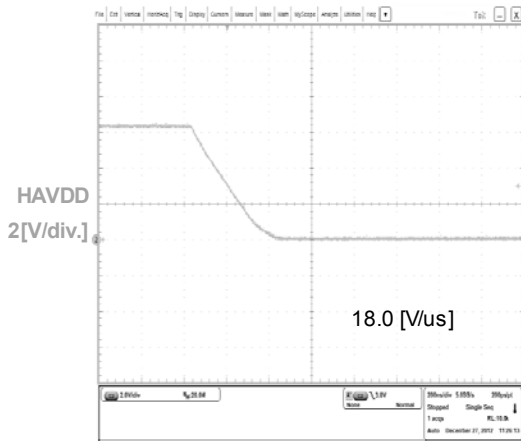


Fig.36 HAVDD Source Current



200[ns/div.]

Fig.37 HAVDD Slew Rate (Rise)



200[ns/div.]

Fig.38 HAVDD Slew Rate (Fall)

●Reference Data  
(Unless otherwise specified, Ta=25°C, VCC, PVCC1, PVCC2=3.3V, VDD1=2.5V, VDD2=1.2V, AVDD=10.5V, VGH=18V, VGL=-6V, HAVDD=5.25V, VCOM=3.25V, no load)

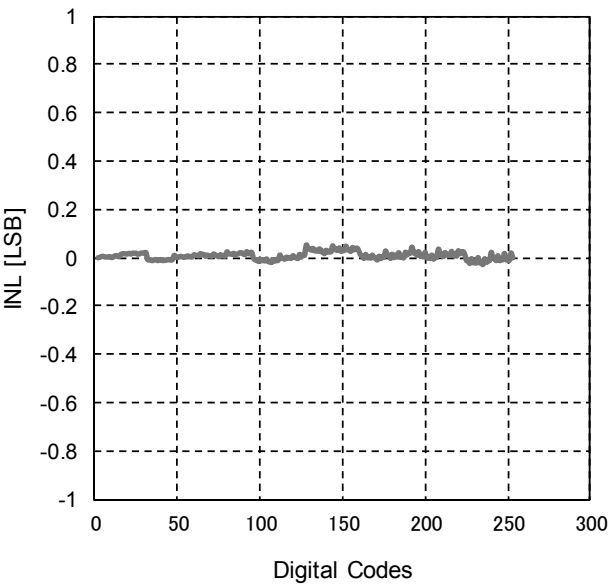


Fig.39 HAVDD INL

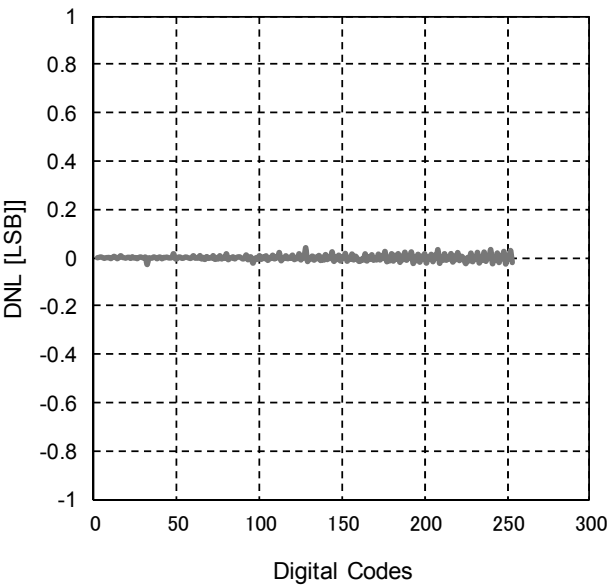


Fig.40 HAVDD DNL

●Reference Data  
(Unless otherwise specified, Ta=25°C, VCC, PVCC1, PVCC2=3.3V, VDD1=2.5V, VDD2=1.2V, AVDD=10.5V, VGH=18V, VGL=-6V, HAVDD=5.25V, VCOM=3.25V, no load)

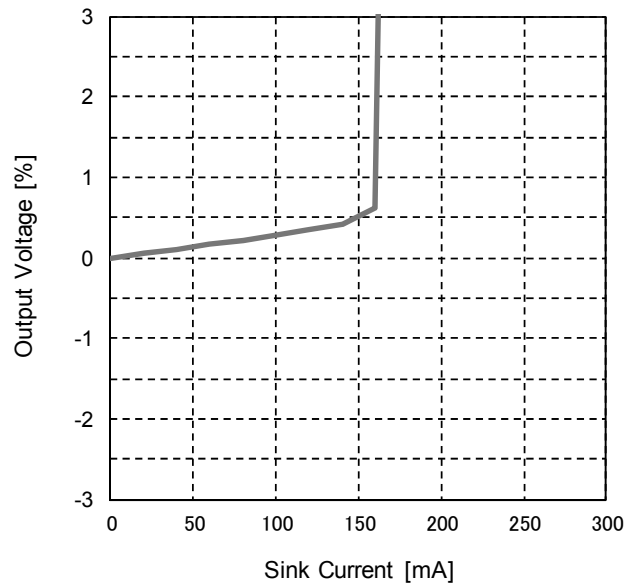


Fig.41 VCOM Sink Current

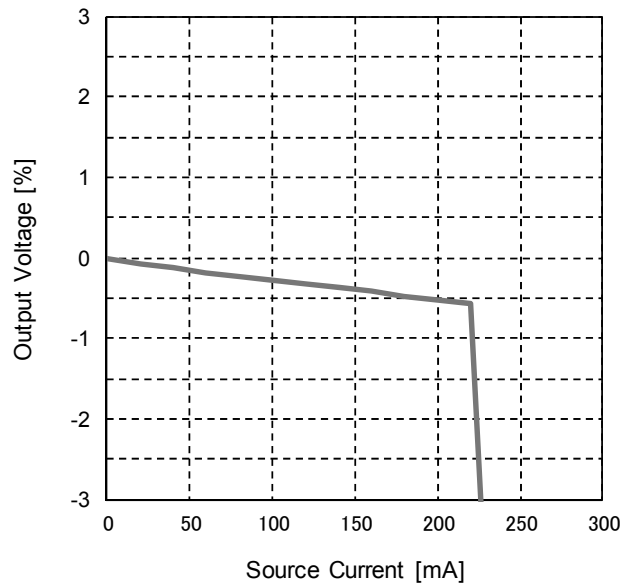
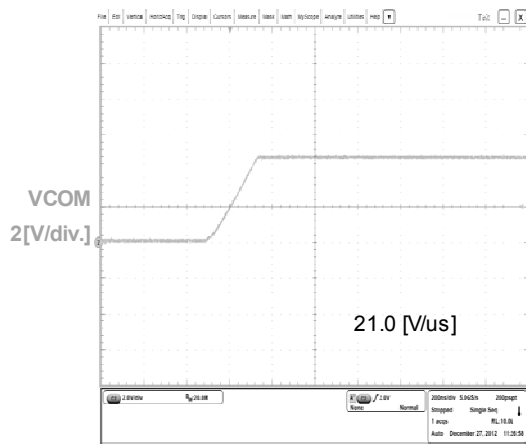
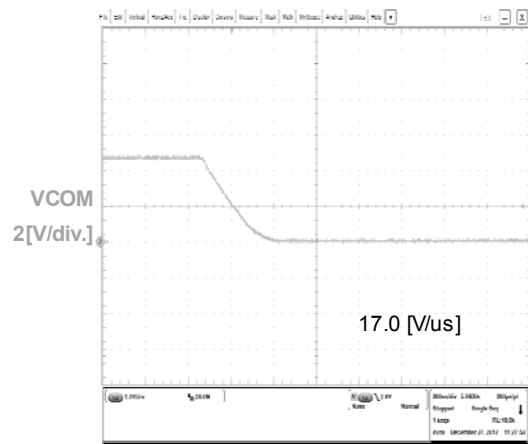


Fig.42 VCOM Source Current



200[ns/div.]

Fig.43 VCOM Slew Rate (Rise)



200[ns/div.]

Fig.44 VCOM Slew Rate (Fall)

●Reference Data  
(Unless otherwise specified, Ta=25°C, VCC, PVCC1, PVCC2=3.3V, VDD1=2.5V, VDD2=1.2V, AVDD=10.5V, VGH=18V, VGL=-6V, HAVDD=5.25V, VCOM=3.25V, no load)

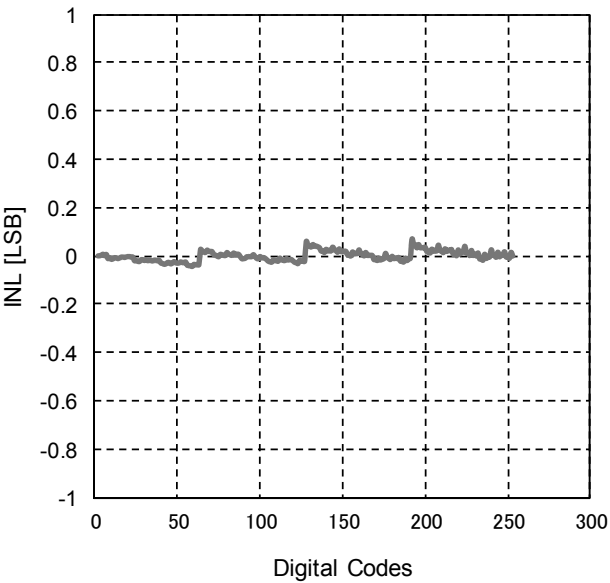


Fig.45 VCOM INL

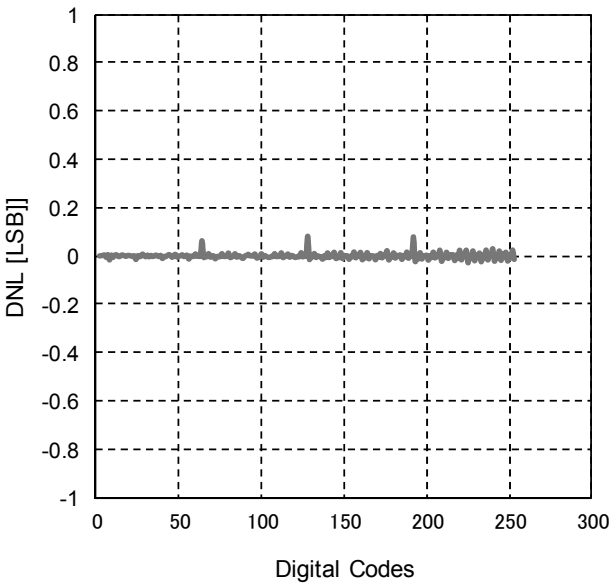


Fig.46 VCOM DNL

## ●Timing Chart1

## ●Start-up Sequence (when operated by EN control)

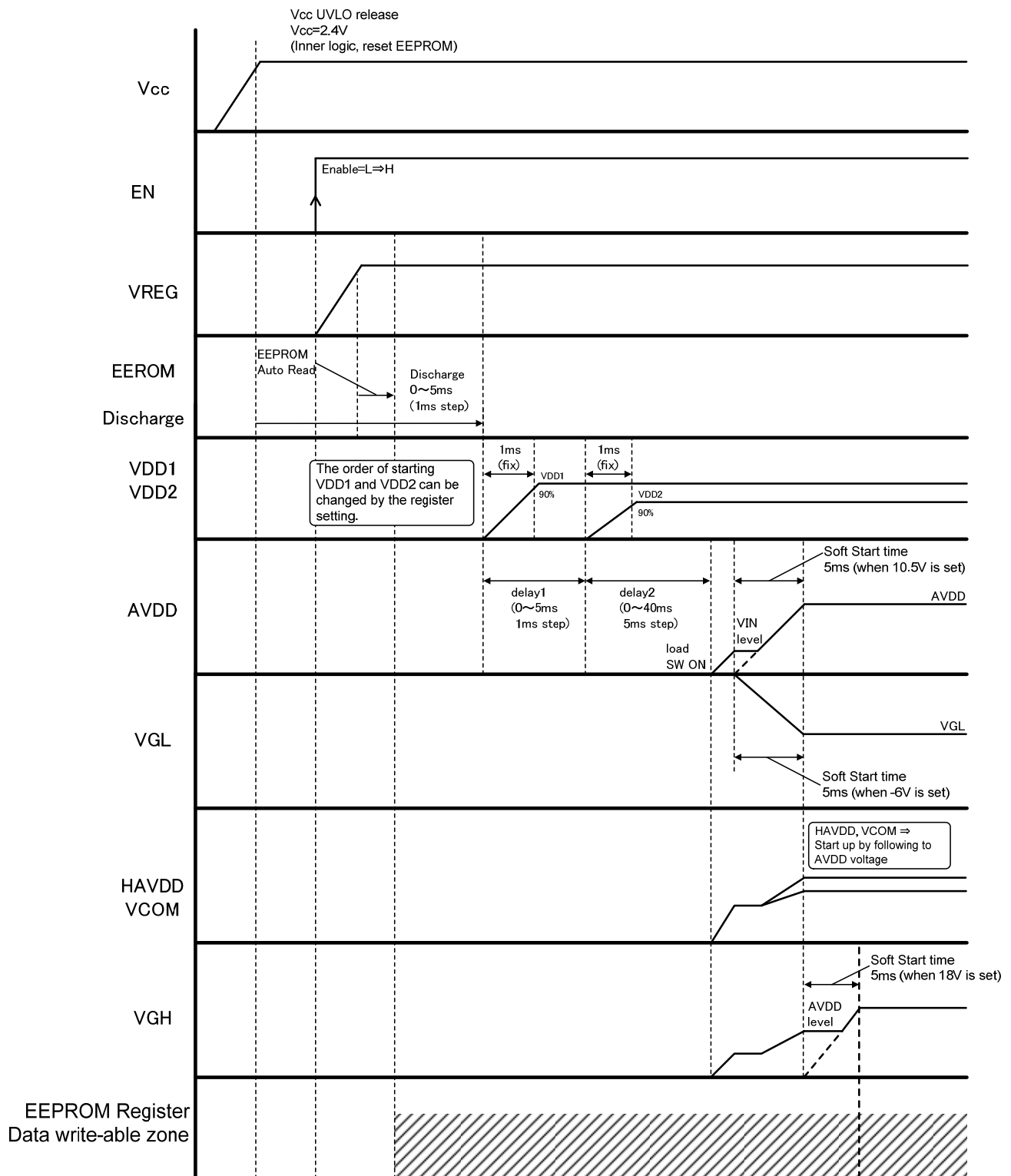


Fig.47 Start-Up Sequence Diagram (when operated by EN control)

●Timing Chart1

●OFF Sequence (when operated by EN control)

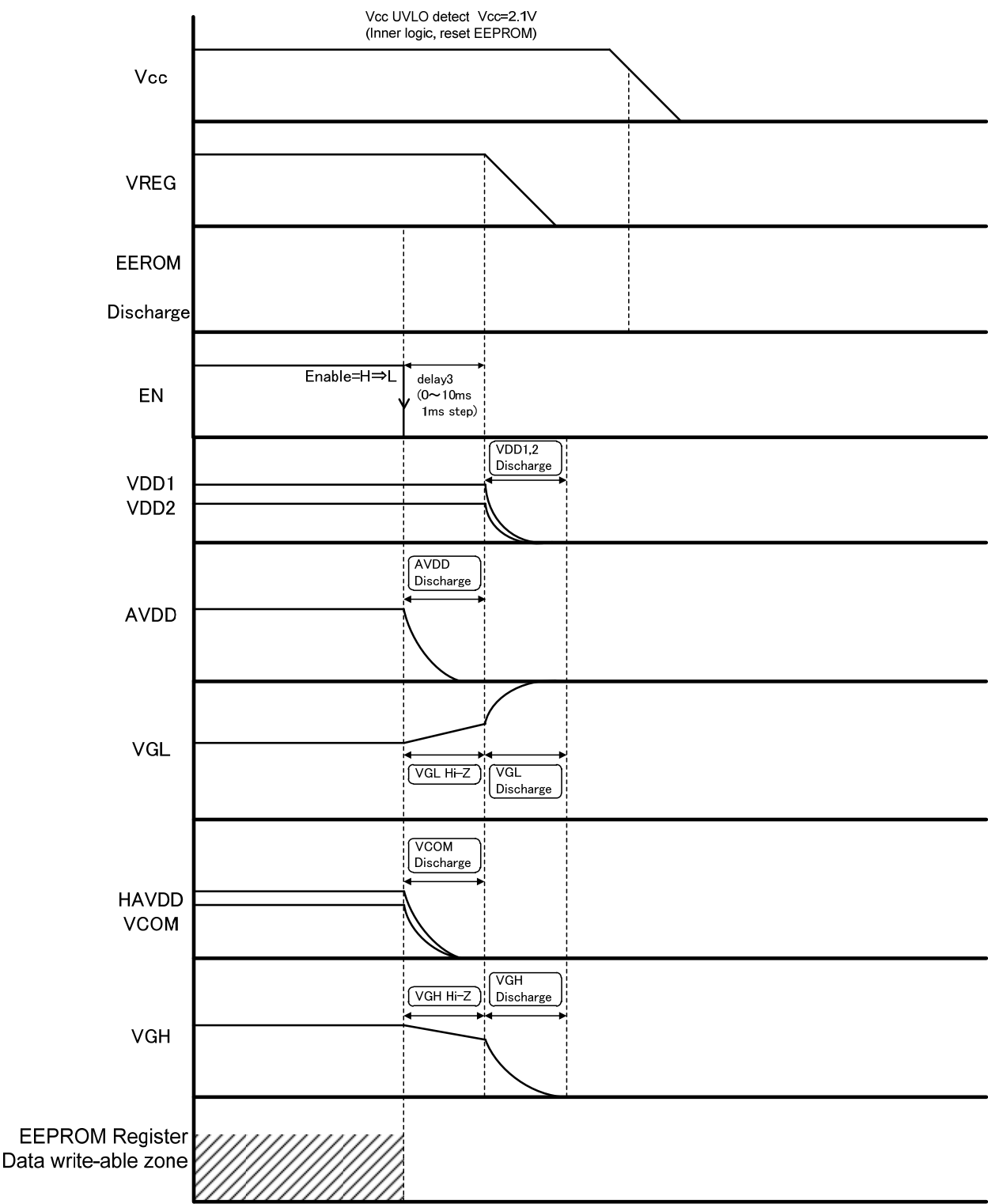


Fig.48 OFF Sequence Block (when operated by EN control)

●Timing Chart2

●Start-up Sequence (when operated with EN= VCC condition)

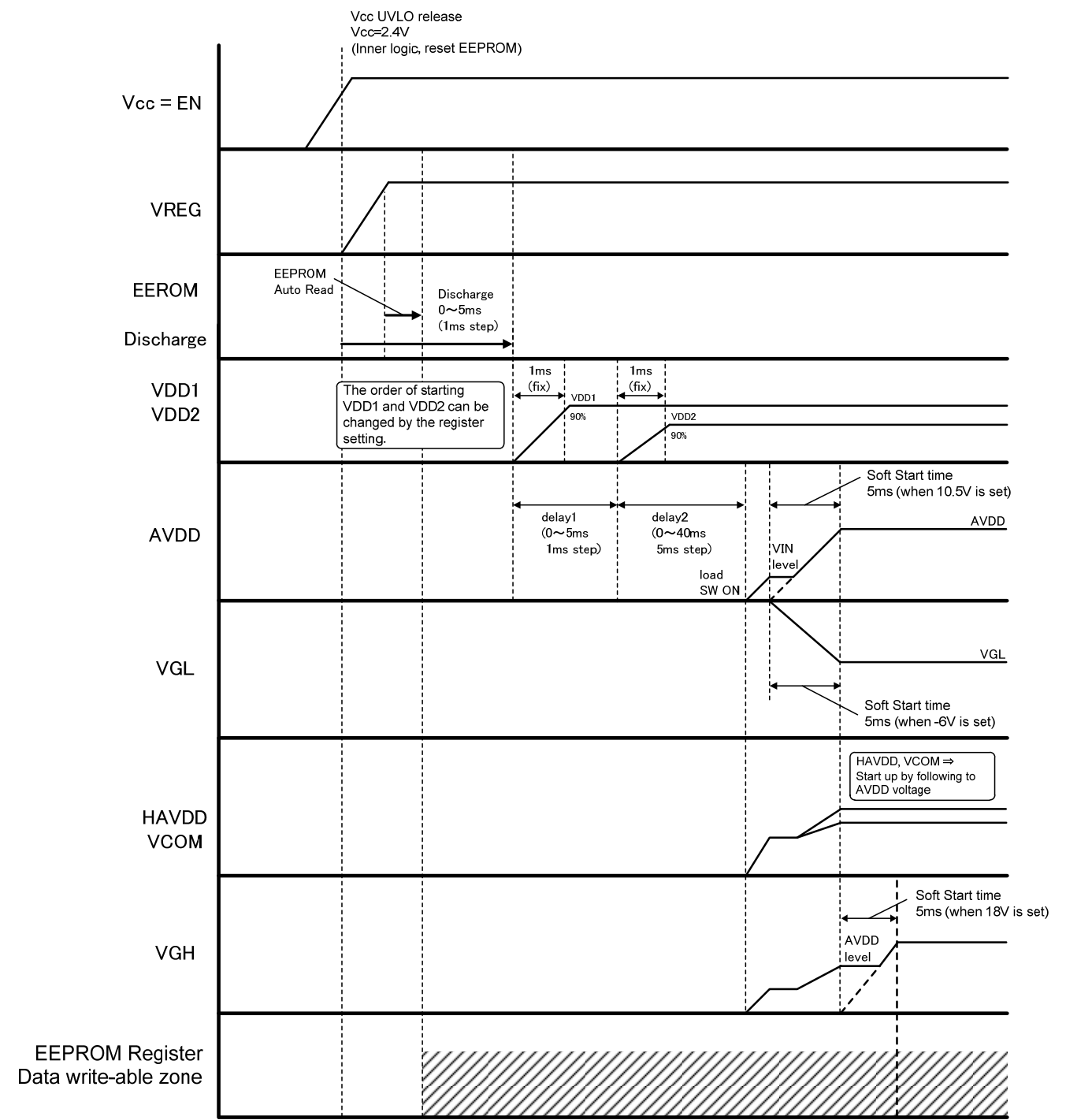


Fig.49 Start-Up Sequence Diagram (when operated with EN= VCC condition)



●Timing Chart2

●OFF Sequence (when operated with EN= VCC condition)

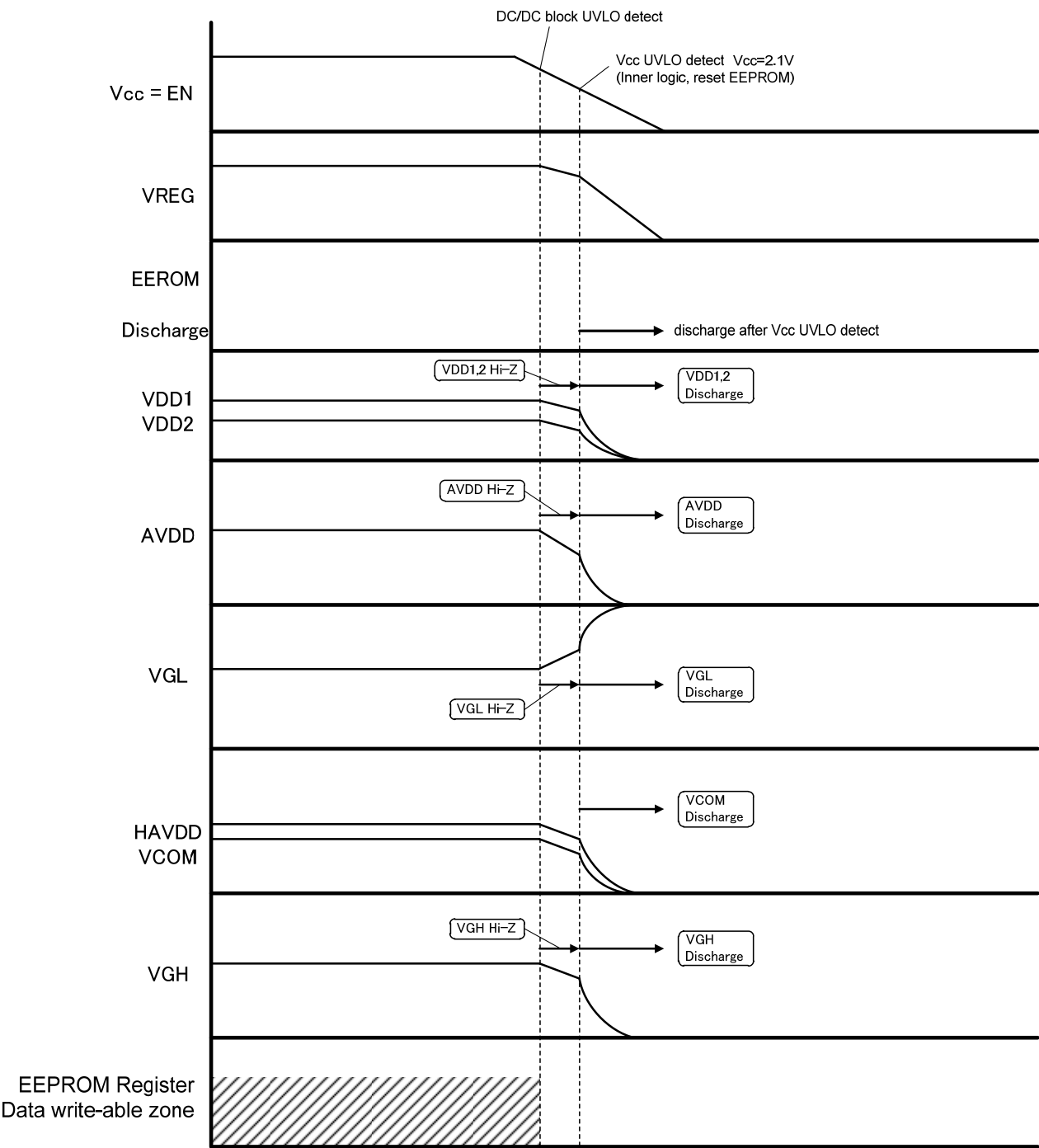


Fig.50 OFF Sequence Diagram (when operated with EN= VCC condition)

●Application Example

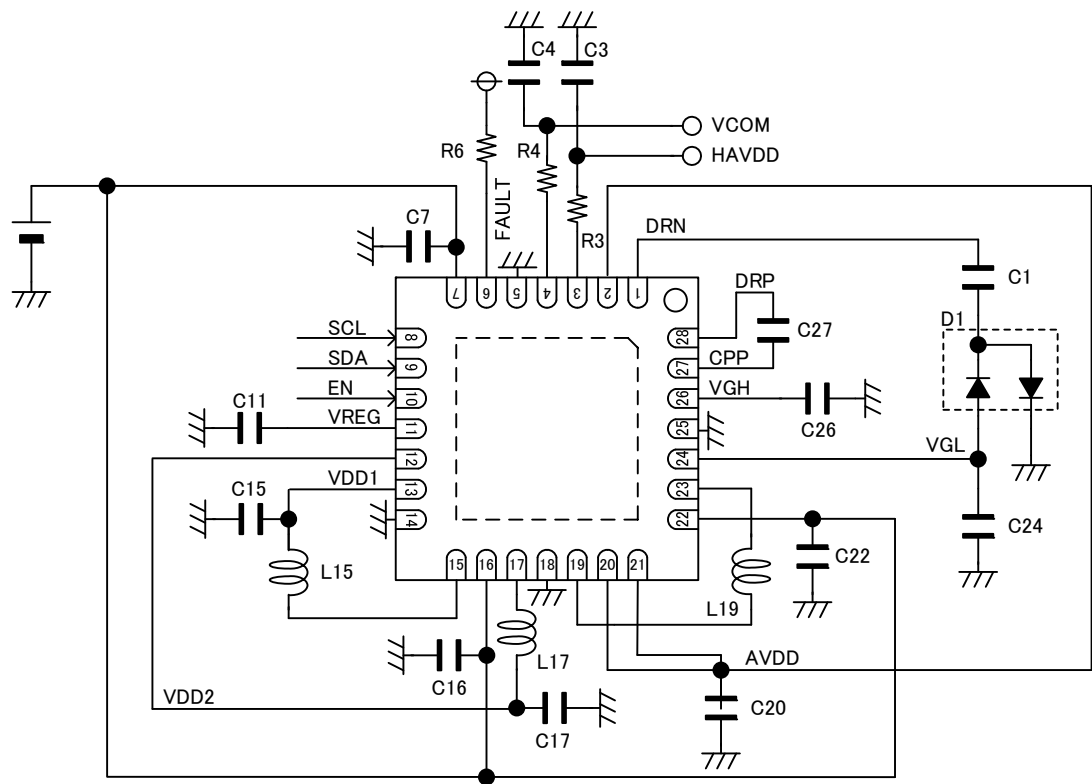


Fig.51 Application Example

| Parts name | Value      | Company     | Parts Number       | Parts name | Value   | Company | Parts Number       |
|------------|------------|-------------|--------------------|------------|---------|---------|--------------------|
| C1         | 0.1 [μF]   | MURATA      | GRM155R61H104KE14D | C24        | 1[μF]   | MURATA  | GRM188B31C105KA92D |
| C3         | 22[μF]     | TAIYO YUDEN | EMK316ABJ226KD-T   | C26        | 1[μF]   | MURATA  | GRM219B31H105KA73  |
| C4         | 22[μF]     | TAIYO YUDEN | EMK316ABJ226KD-T   | C27        | 0.1[μF] | MURATA  | GRM155R61H104KE14D |
| C7         | 4.7[μF]    | TAIYO YUDEN | LMK107BJ475KA-T    | R3         | 10[Ω]   | ROHM    | MCR03EZPD          |
| C11        | 1[μF]      | MURATA      | GRM188B31C105KA92D | R4         | 10[Ω]   | ROHM    | MCR03EZPD          |
| C15        | 10[μF]     | TAIYO YUDEN | JMK107BJ106MA-T    | R6         | 100[kΩ] | ROHM    | MCR03EZPD          |
| C16        | 4.7[μF]    | TAIYO YUDEN | LMK107BJ475KA-T    | D1         | -       | ROHM    | RB558W             |
| C17        | 10[μF]     | TAIYO YUDEN | JMK107BJ106MA-T    | L15        | 4.7[μH] | TOKO    | 1269AS-H-4R7M      |
| C20        | 10[μF] × 2 | TAIYO YUDEN | TMK316ABJ106KD-T   | L17        | 4.7[μH] | TOKO    | 1269AS-H-4R7M      |
| C22        | 4.7[μF]    | TAIYO YUDEN | LMK107BJ475KA-T    | L19        | 4.7[μH] | TOKO    | 1276AS-H-4R7M      |

### ●Selecting Application Components

#### •Selecting the Output LC Constant (Buck Converter : VDD1, VDD2)

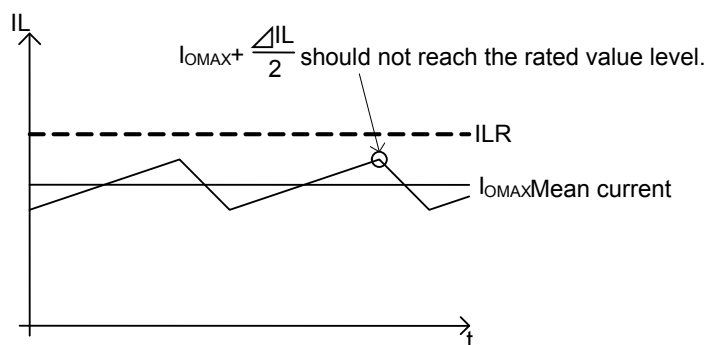


Fig.52 Inductor Current Waveform (Buck Converter : VDD)

The output inductance (L) is decided by the rated current ( $I_{LR}$ ) and maximum input current ( $I_{OMAX}$ ) of the inductance. Adjust so that  $I_{OMAX} + \Delta I_L / 2$  does not reach the rated current value.

$\Delta I_L$  can be obtained by the following equation.

$$\Delta I_L = \frac{1}{L} \times (V_{IN} - V_O) \times \frac{V_O}{V_{IN}} \times \frac{1}{f} \text{ [A]}$$

where  $f$  is the switching frequency

Set with sufficient margin because the inductance value may have a dispersion of  $\pm 30\%$ .

If the coil current exceeds the rated current ( $I_{LR}$ ), the IC may be damaged.

The output capacitor ( $C_O$ ) smoothers the ripple voltage at the output. Select a capacitor that will regulate the output ripple voltage within the specifications.

Output ripple voltage can be obtained by the following equation.

$$\Delta V_{PP} = \Delta I_L \times R_{ESR} + \frac{\Delta I_L}{2 C_O} \times \frac{V_O}{V_{IN}} \times \frac{1}{f}$$

However, since the aforementioned conditions are based on a lot of factors, verify the results using the actual product.

### •Selecting the Output LC Constant (Boost Converter : AVDD)

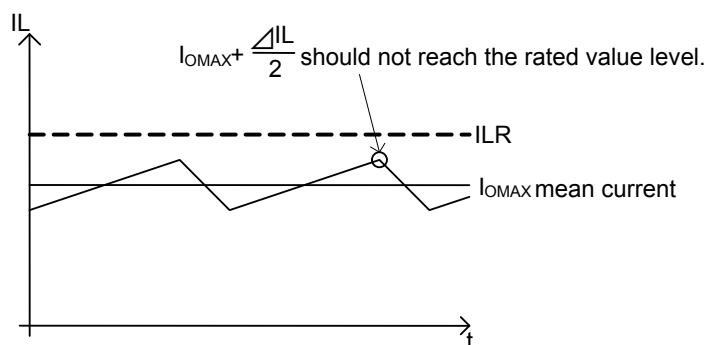


Fig.53 Inductor Current Waveform ( Boost Converter : AVDD )

The output inductance (L) is decided by the rated current ( $I_{LR}$ ) and maximum input current ( $I_{LMAX}$ ) of the inductance. Adjust so that  $I_{LMAX} + \Delta I_L / 2$  does not reach the rated current value.

$\Delta I_L$  can be obtained by the following equation.

$$\Delta I_L = \frac{1}{L} V_{IN} \times \frac{V_O - V_{IN}}{V_O} \times \frac{1}{f} [A]$$

where f is the switching frequency

Set with sufficient margin because the inductance value may have a dispersion of  $\pm 30\%$ .

If the coil current exceeds the rated current ( $I_{LR}$ ), the IC may be damaged.

The output capacitor ( $C_O$ ) smoothens the ripple voltage at the output. Select a capacitor that will regulate the output ripple voltage within the specifications.

Output ripple voltage can be obtained by the following equation.

$$\Delta V_{PP} = I_{LMAX} \times R_{ESR} + \frac{1}{f \times C_O} \times \frac{V_{IN}}{V_O} \times \left( I_{LMAX} - \frac{\Delta I_L}{2} \right)$$

However, since the aforementioned conditions are based on a lot of factors, verify the results using the actual product.

## •Serial Transmission

BD81028AMWV uses the I<sup>2</sup>C bus in communicating with host addresses.

The device/slave address is always followed by the 1 byte register/select address as shown in the I<sup>2</sup>C bus format below.

| MSB   |                |    |    |    |    |    |    | LSB |     |     |                  |    |    |    |    | MSB |    |    |     |      |    |    |    | LSB |    |    |  |     |      |  |  | MSB |  |  |  |  |  |  |  | LSB |  |  |  |  |  |  |  |
|-------|----------------|----|----|----|----|----|----|-----|-----|-----|------------------|----|----|----|----|-----|----|----|-----|------|----|----|----|-----|----|----|--|-----|------|--|--|-----|--|--|--|--|--|--|--|-----|--|--|--|--|--|--|--|
| Start | Device address |    |    |    |    |    |    |     | R/W | ACK | Register address |    |    |    |    |     |    |    | ACK | Data |    |    |    |     |    |    |  | ACK | STOP |  |  |     |  |  |  |  |  |  |  |     |  |  |  |  |  |  |  |
|       | A6             | A5 | A4 | A3 | A2 | A1 | A0 | R7  |     |     | R6               | R5 | R4 | R3 | R2 | R1  | R0 | D7 |     | D6   | D5 | D4 | D3 | D2  | D1 | D0 |  |     |      |  |  |     |  |  |  |  |  |  |  |     |  |  |  |  |  |  |  |

- Start : Start bit
- Device Address : Consists of 8 bits in total (A6 to A0 and the R/W bit) (MSB fast).  
If the R/W bit is H, this means read mode.  
If the R/W bit is L, this means write mode.
- ACK : Acknowledge bit.  
When sending and receiving data, there should be an acknowledge bit after each byte.  
If data is sent and received properly, 'L' is replied to the sender.  
If data is not received properly, 'H' is replied to the sender.
- Register Address : 1 byte select address.
- Data : Data byte. Sending and Receiving data (MSB Fast)
- STOP : Stop bit

There are two writing modes from I<sup>2</sup>C bus to the registers, single mode and multi mode.

In single mode, communication is sent to a single register.

In multi mode, communication is sent to multiple registers by entering multiple data before the stop bit.

## •Device address

Slave address specific to the IC is 1000000 (A6 to A0).

## •Register address

R7 is for TEST MODE. Normally, this should be set to 0.

R6 and R5 are don't care bits.

R4 to R0 are the register address bits.

## •Command interface

Transmission format for data sent and received to the EEPROM is shown below.

### Write operation

- PM I<sup>2</sup>C Write format (Register Address: 01h to 08h)

| Start | Device address |   |   |   |   |   |   |   | R/W | ACK | Register address | ACK | N-bytes Data |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ACK | STOP |
|-------|----------------|---|---|---|---|---|---|---|-----|-----|------------------|-----|--------------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|-----|------|
|       | 1              | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0   | 0   | 01h~08h          | 0   |              |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 0   |      |

Write data in multi mode by entering data continuously after the register address.

Data entry should be 8 bits.

- VCOM I<sup>2</sup>C Write format (Register Address: 09h)

| Start | Device address |   |   |   |   |   |   |   | R/W | ACK | Register address |  |  |  |  |  |  |  | DATA |    |    |    |    |    |    |    | ACK | STOP |
|-------|----------------|---|---|---|---|---|---|---|-----|-----|------------------|--|--|--|--|--|--|--|------|----|----|----|----|----|----|----|-----|------|
|       | 1              | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0   | 0   | 09h              |  |  |  |  |  |  |  | D7   | D6 | D5 | D4 | D3 | D2 | D1 | D0 |     |      |

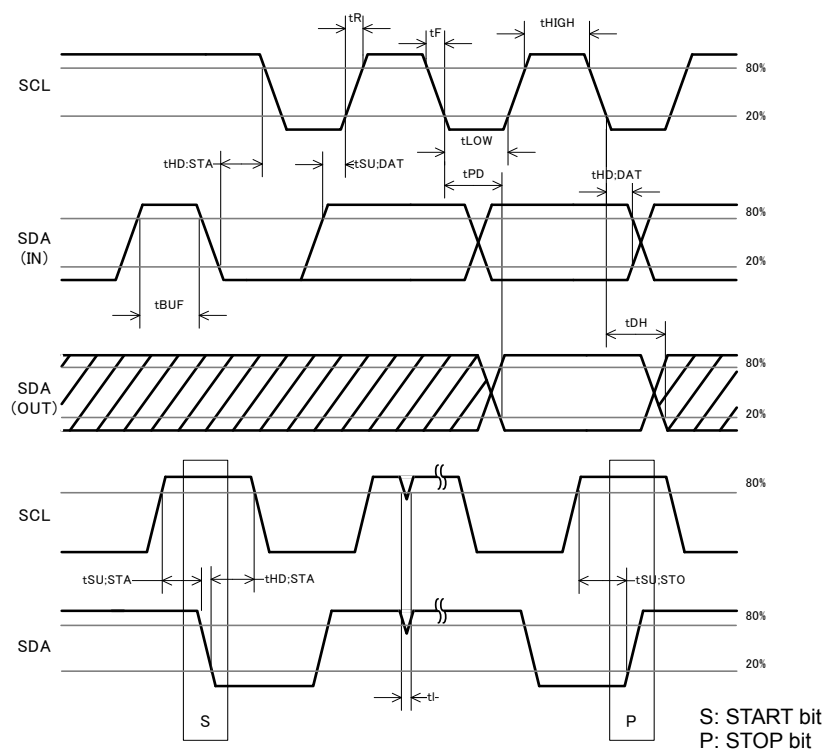
Write data in single mode (VCOM), designate a register address of 09h.

### Read operation

- I<sup>2</sup>C Read format

| Start | Device address |   |   |   |   |   |   |   | R/W | ACK | Register address |  |  |  | ACK | Repeated Start | Device address |   |   |   |   |   |   |   | R/W | ACK | N-bytes Data | ACK | STOP |
|-------|----------------|---|---|---|---|---|---|---|-----|-----|------------------|--|--|--|-----|----------------|----------------|---|---|---|---|---|---|---|-----|-----|--------------|-----|------|
|       | 1              | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0   | 0   | 01h~09h          |  |  |  | 0   |                | 1              | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1   | 0   |              |     |      |

Read data in the PMIC register through the read command.

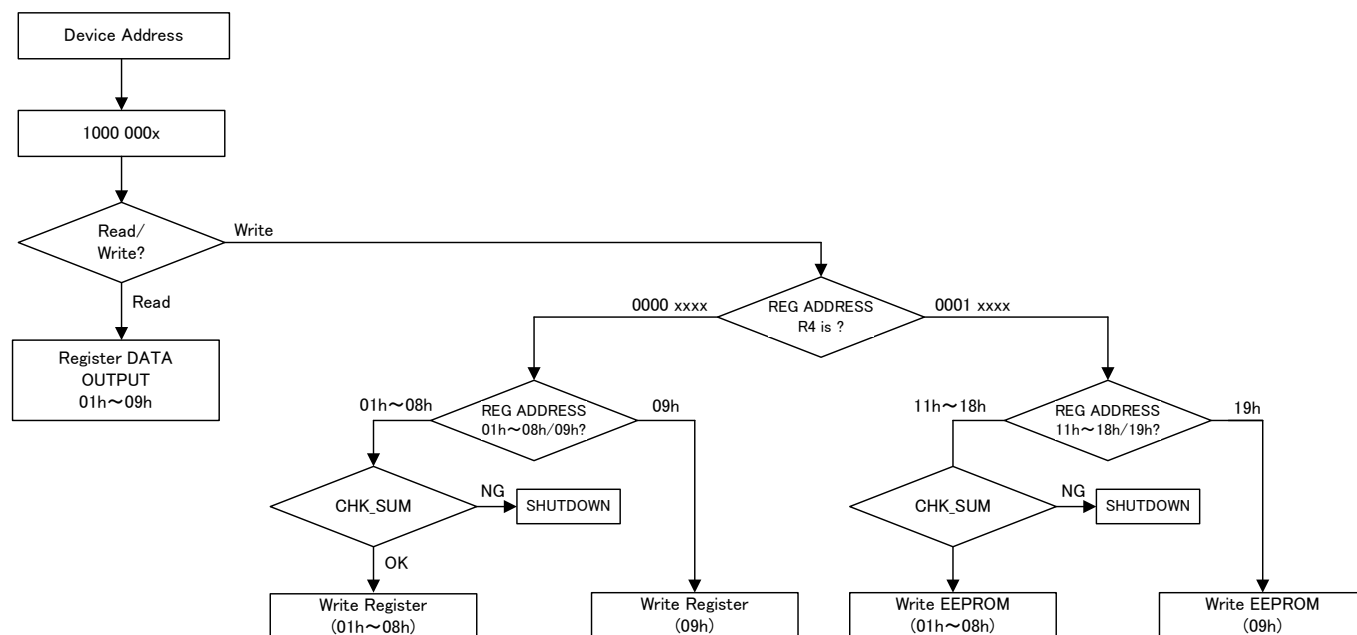
• I<sup>2</sup>C TimingFig.54. I<sup>2</sup>C Timing

## • Timing Specification

| PARAMETER              | SYMBOL       | NORMAL mode |     |     | FAST mode |     |     | Unit    |
|------------------------|--------------|-------------|-----|-----|-----------|-----|-----|---------|
|                        |              | MIN         | TYP | MAX | MIN       | TYP | MAX |         |
| SCL frequency          | $f_{SCL}$    | -           | -   | 100 | -         | -   | 400 | kHz     |
| SCL "H" time           | $t_{HIGH}$   | 4.0         | -   | -   | 0.6       | -   | -   | $\mu s$ |
| SCL "L" time           | $t_{LOW}$    | 4.7         | -   | -   | 1.2       | -   | -   | $\mu s$ |
| Rising time            | $t_R$        | -           | -   | 1.0 | -         | -   | 0.3 | $\mu s$ |
| Falling time           | $t_F$        | -           | -   | 0.3 | -         | -   | 0.3 | $\mu s$ |
| Start bit holding time | $t_{HD:STA}$ | 4.0         | -   | -   | 0.6       | -   | -   | $\mu s$ |
| Start bit setup time   | $t_{SU:STA}$ | 4.7         | -   | -   | 0.6       | -   | -   | $\mu s$ |
| SDA holding time       | $t_{HD:DAT}$ | 200         | -   | -   | 100       | -   | -   | ns      |
| SDA setup time         | $t_{SU:DAT}$ | 200         | -   | -   | 100       | -   | -   | ns      |
| Acknowledge delay time | $t_{PD}$     | -           | -   | 0.9 | -         | -   | 0.9 | $\mu s$ |
| Acknowledge hold time  | $t_{DH}$     | -           | 0.1 | -   | -         | 0.1 | -   | $\mu s$ |
| Stop bit setup time    | $t_{SU:STO}$ | 4.7         | -   | -   | 0.6       | -   | -   | $\mu s$ |
| BUS open time          | $t_{BUF}$    | 4.7         | -   | -   | 1.2       | -   | -   | $\mu s$ |
| Noise spike width      | $t_I$        | -           | 0.1 | -   | -         | 0.1 | -   | $\mu s$ |

### •Writing Data to the Register/EEPROM

After power up and when EN is high, data can be written to the registers or the EEPROM.  
The logic of the register address R4 will determine where the data will be written.  
Check-sum is installed before writing data to prevent malfunctions caused by data error.  
The flowchart of the writing process to the register and EEPROM is shown below.



#### • Writing Data to the Register

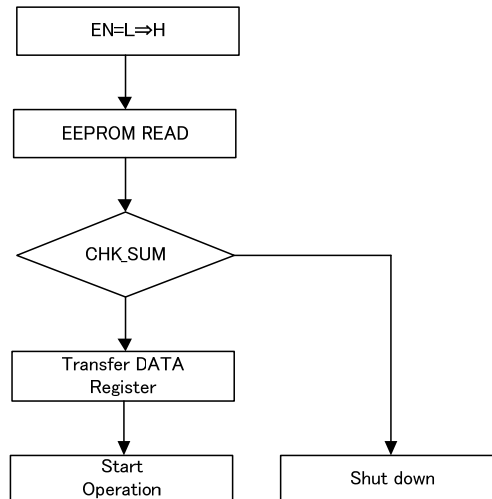
Data is written to the registers when register address R4 is “0”.  
AVDD, VGH, VGL, HAVDD, and VCOM (register address: 01h to 04h) output voltage can be changed by writing data to the registers.

#### • Writing Data to the EEPROM

Data is written to the EEPROM when register address R4 is “1”.  
Upon start-up and EN is high, data which is stored in the EEPROM is copied to the registers.  
Therefore, by writing to the EEPROM, the start-up settings will be changed.

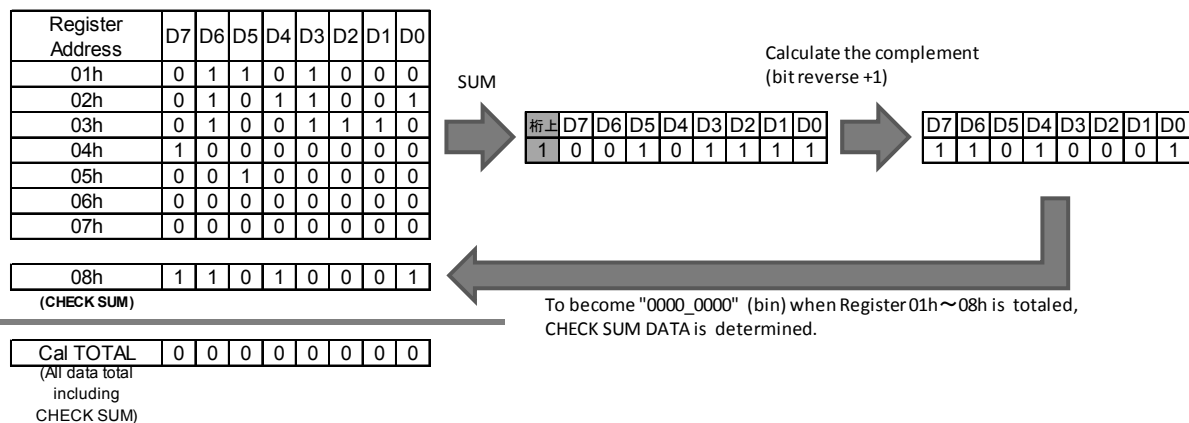
### •Automatic EEPROM Read Function at Start-up

Upon BD81028AMWV start-up, a reset signal is generated and each register is initialized. After that, when EN is changed from low to high, data which is stored in the EEPROM is copied to the registers. Furthermore, the check-sum function is installed to prevent malfunctions caused by data error. The automatic EEPROM read function at start-up is further explained by the flow chart below.



### •Check-Sum Data

If data is written to the Register and EEPROM, it is necessary to set check-sum data to prevent malfunctions caused by data error. Check-sum data is the complement of the sum of all data. When check-sum data is added to the sum of all data, the result should be zero.



### •Return to Normal Operation after Shutdown at Check-Sum Error

A check-sum of zero indicates a data error and this causes the PMIC to latch in shutdown. There are two ways to reactivate the PMIC. First, write to the EEPROM the correct data while the power supply is turned on and EN=L; then toggle EN to H. Lastly, reset the power supply and enter the correct data while EN=H.



## ●EEPROM Parameter Setting

| Register Address | Bits | Function                                                                                                | Default                    | Resolution                                                                        |
|------------------|------|---------------------------------------------------------------------------------------------------------|----------------------------|-----------------------------------------------------------------------------------|
| 01h              | 8    | AVDD Output voltage setting                                                                             | 9.8V                       | 0.1V<br>[8V to 14.5V]                                                             |
| 02h              | 8    | VGH Output voltage setting                                                                              | 18V                        | 0.2V<br>[13V to 26V]                                                              |
| 03h              | 8    | VGL Output voltage setting                                                                              | -6.0V                      | 0.1V<br>[-9.5V to -4.0]                                                           |
| 04h              | 8    | HAVDD Output voltage setting                                                                            | 4.23V                      | 12.5mV                                                                            |
| 05h              | 8    | VDD1 Output voltage setting [3:0]<br>VDD2 Output voltage setting [6:4]<br>VDD startup order setting [7] | 1.8V<br>1.2V<br>0          | 0.05V [1.7 to 1.9, 2.4 to 2.6V]<br>0.05V [1.1V to 1.3V]<br>0 : VDD1→2, 1 : VDD2→1 |
| 06h              | 7    | Discharge time setting [2:0]<br>DELAY1 time setting [5:3]<br>DC/DC UVLO detect/release voltage [7:6]    | 0msec<br>0msec<br>2.5/2.7V | 1msec [0 to 5msec]<br>1msec [0 to 5msec]<br>0.2V step                             |
| 07h              | 7    | DELAY2 time setting [2:0]<br>DELAY3 time setting [6:3]<br>Frequency setting [7]                         | 30msec<br>0msec<br>1200kHz | 5msec [0 to 40msec]<br>2msec [0 to 10msec]<br>0 : 600kHz, 1 : 1200kHz             |
| 08h              | 8    | 8 bit Check-sum                                                                                         | 42h                        | —                                                                                 |
| 09h              | 8    | VCOM Output voltage setting                                                                             | 2.1225V                    | 12.5mV                                                                            |

## ●Register map

| Resister Address | D7             | D6           | D5          | D4 | D3           | D2          | D1 | D0 |
|------------------|----------------|--------------|-------------|----|--------------|-------------|----|----|
| 01h              | AVDD [7:0]     |              |             |    |              |             |    |    |
| 02h              | VGH [7:0]      |              |             |    |              |             |    |    |
| 03h              | VGL [7:0]      |              |             |    |              |             |    |    |
| 04h              | HAVDD [7:0]    |              |             |    |              |             |    |    |
| 05h              | SEQ[0]         | VDD2 [2:0]   |             |    | VDD1 [3:0]   |             |    |    |
| 06h              | UVLO[1:0]      |              | DELAY1[2:0] |    |              | DISCHG[2:0] |    |    |
| 07h              | FREQ[0]        | DELAY3 [2:0] |             |    | DELAY2 [3:0] |             |    |    |
| 08h              | CHECK SUM[7:0] |              |             |    |              |             |    |    |
| 09h              | VCOM [7:0]     |              |             |    |              |             |    |    |

## ●Command Table 1

| DATA |      | Register                          |                                  |                                  |                                    |                       |                                   |                                   |                                                |                                     |                                        |                               |                                     |                                     |                                   |
|------|------|-----------------------------------|----------------------------------|----------------------------------|------------------------------------|-----------------------|-----------------------------------|-----------------------------------|------------------------------------------------|-------------------------------------|----------------------------------------|-------------------------------|-------------------------------------|-------------------------------------|-----------------------------------|
|      |      | 01h                               | 02h                              | 03h                              | 04h                                | 05h                   |                                   |                                   | 06h                                            |                                     |                                        | 07h                           |                                     |                                     | 09h                               |
|      |      | AVDD<br>Voltage<br>Setting<br>[V] | VGH<br>Voltage<br>Setting<br>[V] | VGL<br>Voltage<br>Setting<br>[V] | HAVDD<br>Voltage<br>Setting<br>[V] | VDD<br>ON<br>Sequence | VDD2<br>Voltage<br>Setting<br>[V] | VDD1<br>Voltage<br>Setting<br>[V] | DC/DC UVLO<br>Detect/Release<br>Voltage<br>[V] | DELAY1<br>Time<br>Setting<br>[msec] | Discharge<br>Time<br>Setting<br>[msec] | Frequency<br>Setting<br>[kHz] | DELAY3<br>Time<br>Setting<br>[msec] | DELAY2<br>Time<br>Setting<br>[msec] | VCOM<br>Voltage<br>Setting<br>[V] |
| DEC. | HEX. |                                   |                                  |                                  |                                    |                       |                                   |                                   |                                                |                                     |                                        |                               |                                     |                                     |                                   |
| 0    | 00   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD                         | VDD1→VDD2             | 1.10                              | 1.70                              | 2.5 / 2.7                                      | 0                                   | 0                                      | 600                           | 0                                   | 0                                   | 0.45 × AVDD                       |
| 1    | 01   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.0125                  | VDD1→VDD2             | 1.10                              | 1.75                              | 2.5 / 2.7                                      | 0                                   | 1                                      | 600                           | 0                                   | 5                                   | 0.45 × AVDD-0.0125                |
| 2    | 02   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.0250                  | VDD1→VDD2             | 1.10                              | 1.80                              | 2.5 / 2.7                                      | 0                                   | 2                                      | 600                           | 0                                   | 10                                  | 0.45 × AVDD-0.0250                |
| 3    | 03   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.0375                  | VDD1→VDD2             | 1.10                              | 1.85                              | 2.5 / 2.7                                      | 0                                   | 3                                      | 600                           | 0                                   | 15                                  | 0.45 × AVDD-0.0375                |
| 4    | 04   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.0500                  | VDD1→VDD2             | 1.10                              | 1.90                              | 2.5 / 2.7                                      | 0                                   | 4                                      | 600                           | 0                                   | 20                                  | 0.45 × AVDD-0.0500                |
| 5    | 05   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.0625                  | VDD1→VDD2             | 1.10                              | 2.40                              | 2.5 / 2.7                                      | 0                                   | 5                                      | 600                           | 0                                   | 25                                  | 0.45 × AVDD-0.0625                |
| 6    | 06   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.0750                  | VDD1→VDD2             | 1.10                              | 2.45                              | 2.5 / 2.7                                      | 0                                   | 0                                      | 600                           | 0                                   | 30                                  | 0.45 × AVDD-0.0750                |
| 7    | 07   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.0875                  | VDD1→VDD2             | 1.10                              | 2.50                              | 2.5 / 2.7                                      | 0                                   | 0                                      | 600                           | 0                                   | 35                                  | 0.45 × AVDD-0.0875                |
| 8    | 08   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.1000                  | VDD1→VDD2             | 1.10                              | 2.55                              | 2.5 / 2.7                                      | 1                                   | 0                                      | 600                           | 0                                   | 40                                  | 0.45 × AVDD-0.1000                |
| 9    | 09   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.1125                  | VDD1→VDD2             | 1.10                              | 2.60                              | 2.5 / 2.7                                      | 1                                   | 1                                      | 600                           | 0                                   | 0                                   | 0.45 × AVDD-0.1125                |
| 10   | 0A   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.1250                  | VDD1→VDD2             | 1.10                              | 2.60                              | 2.5 / 2.7                                      | 1                                   | 2                                      | 600                           | 0                                   | 0                                   | 0.45 × AVDD-0.1250                |
| 11   | 0B   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.1375                  | VDD1→VDD2             | 1.10                              | 2.60                              | 2.5 / 2.7                                      | 1                                   | 3                                      | 600                           | 0                                   | 0                                   | 0.45 × AVDD-0.1375                |
| 12   | 0C   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.1500                  | VDD1→VDD2             | 1.10                              | 2.60                              | 2.5 / 2.7                                      | 1                                   | 4                                      | 600                           | 0                                   | 0                                   | 0.45 × AVDD-0.1500                |
| 13   | 0D   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.1625                  | VDD1→VDD2             | 1.10                              | 2.60                              | 2.5 / 2.7                                      | 1                                   | 5                                      | 600                           | 0                                   | 0                                   | 0.45 × AVDD-0.1625                |
| 14   | 0E   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.1750                  | VDD1→VDD2             | 1.10                              | 2.60                              | 2.5 / 2.7                                      | 1                                   | 0                                      | 600                           | 0                                   | 0                                   | 0.45 × AVDD-0.1750                |
| 15   | 0F   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.1875                  | VDD1→VDD2             | 1.10                              | 2.60                              | 2.5 / 2.7                                      | 1                                   | 0                                      | 600                           | 0                                   | 0                                   | 0.45 × AVDD-0.1875                |
| 16   | 10   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.2000                  | VDD1→VDD2             | 1.15                              | 1.70                              | 2.5 / 2.7                                      | 2                                   | 0                                      | 600                           | 2                                   | 0                                   | 0.45 × AVDD-0.2000                |
| 17   | 11   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.2125                  | VDD1→VDD2             | 1.15                              | 1.75                              | 2.5 / 2.7                                      | 2                                   | 1                                      | 600                           | 2                                   | 5                                   | 0.45 × AVDD-0.2125                |
| 18   | 12   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.2250                  | VDD1→VDD2             | 1.15                              | 1.80                              | 2.5 / 2.7                                      | 2                                   | 2                                      | 600                           | 2                                   | 10                                  | 0.45 × AVDD-0.2250                |
| 19   | 13   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.2375                  | VDD1→VDD2             | 1.15                              | 1.85                              | 2.5 / 2.7                                      | 2                                   | 3                                      | 600                           | 2                                   | 15                                  | 0.45 × AVDD-0.2375                |
| 20   | 14   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.2500                  | VDD1→VDD2             | 1.15                              | 1.90                              | 2.5 / 2.7                                      | 2                                   | 4                                      | 600                           | 2                                   | 20                                  | 0.45 × AVDD-0.2500                |
| 21   | 15   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.2625                  | VDD1→VDD2             | 1.15                              | 2.40                              | 2.5 / 2.7                                      | 2                                   | 5                                      | 600                           | 2                                   | 25                                  | 0.45 × AVDD-0.2625                |
| 22   | 16   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.2750                  | VDD1→VDD2             | 1.15                              | 2.45                              | 2.5 / 2.7                                      | 2                                   | 0                                      | 600                           | 2                                   | 30                                  | 0.45 × AVDD-0.2750                |
| 23   | 17   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.2875                  | VDD1→VDD2             | 1.15                              | 2.50                              | 2.5 / 2.7                                      | 2                                   | 0                                      | 600                           | 2                                   | 35                                  | 0.45 × AVDD-0.2875                |
| 24   | 18   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.3000                  | VDD1→VDD2             | 1.15                              | 2.55                              | 2.5 / 2.7                                      | 3                                   | 0                                      | 600                           | 2                                   | 40                                  | 0.45 × AVDD-0.3000                |
| 25   | 19   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.3125                  | VDD1→VDD2             | 1.15                              | 2.60                              | 2.5 / 2.7                                      | 3                                   | 1                                      | 600                           | 2                                   | 0                                   | 0.45 × AVDD-0.3125                |
| 26   | 1A   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.3250                  | VDD1→VDD2             | 1.15                              | 2.60                              | 2.5 / 2.7                                      | 3                                   | 2                                      | 600                           | 2                                   | 0                                   | 0.45 × AVDD-0.3250                |
| 27   | 1B   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.3375                  | VDD1→VDD2             | 1.15                              | 2.60                              | 2.5 / 2.7                                      | 3                                   | 3                                      | 600                           | 2                                   | 0                                   | 0.45 × AVDD-0.3375                |
| 28   | 1C   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.3500                  | VDD1→VDD2             | 1.15                              | 2.60                              | 2.5 / 2.7                                      | 3                                   | 4                                      | 600                           | 2                                   | 0                                   | 0.45 × AVDD-0.3500                |
| 29   | 1D   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.3625                  | VDD1→VDD2             | 1.15                              | 2.60                              | 2.5 / 2.7                                      | 3                                   | 5                                      | 600                           | 2                                   | 0                                   | 0.45 × AVDD-0.3625                |
| 30   | 1E   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.3750                  | VDD1→VDD2             | 1.15                              | 2.60                              | 2.5 / 2.7                                      | 3                                   | 0                                      | 600                           | 2                                   | 0                                   | 0.45 × AVDD-0.3750                |
| 31   | 1F   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.3875                  | VDD1→VDD2             | 1.15                              | 2.60                              | 2.5 / 2.7                                      | 3                                   | 0                                      | 600                           | 2                                   | 0                                   | 0.45 × AVDD-0.3875                |
| 32   | 20   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.4000                  | VDD1→VDD2             | 1.20                              | 1.70                              | 2.5 / 2.7                                      | 4                                   | 0                                      | 600                           | 4                                   | 0                                   | 0.45 × AVDD-0.4000                |
| 33   | 21   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.4125                  | VDD1→VDD2             | 1.20                              | 1.75                              | 2.5 / 2.7                                      | 4                                   | 1                                      | 600                           | 4                                   | 5                                   | 0.45 × AVDD-0.4125                |
| 34   | 22   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.4250                  | VDD1→VDD2             | 1.20                              | 1.80                              | 2.5 / 2.7                                      | 4                                   | 2                                      | 600                           | 4                                   | 10                                  | 0.45 × AVDD-0.4250                |
| 35   | 23   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.4375                  | VDD1→VDD2             | 1.20                              | 1.85                              | 2.5 / 2.7                                      | 4                                   | 3                                      | 600                           | 4                                   | 15                                  | 0.45 × AVDD-0.4375                |
| 36   | 24   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.4500                  | VDD1→VDD2             | 1.20                              | 1.90                              | 2.5 / 2.7                                      | 4                                   | 4                                      | 600                           | 4                                   | 20                                  | 0.45 × AVDD-0.4500                |
| 37   | 25   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.4625                  | VDD1→VDD2             | 1.20                              | 2.40                              | 2.5 / 2.7                                      | 4                                   | 5                                      | 600                           | 4                                   | 25                                  | 0.45 × AVDD-0.4625                |
| 38   | 26   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.4750                  | VDD1→VDD2             | 1.20                              | 2.45                              | 2.5 / 2.7                                      | 4                                   | 0                                      | 600                           | 4                                   | 30                                  | 0.45 × AVDD-0.4750                |
| 39   | 27   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.4875                  | VDD1→VDD2             | 1.20                              | 2.50                              | 2.5 / 2.7                                      | 4                                   | 0                                      | 600                           | 4                                   | 35                                  | 0.45 × AVDD-0.4875                |
| 40   | 28   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.5000                  | VDD1→VDD2             | 1.20                              | 2.55                              | 2.5 / 2.7                                      | 5                                   | 0                                      | 600                           | 4                                   | 40                                  | 0.45 × AVDD-0.5000                |
| 41   | 29   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.5125                  | VDD1→VDD2             | 1.20                              | 2.60                              | 2.5 / 2.7                                      | 5                                   | 1                                      | 600                           | 4                                   | 0                                   | 0.45 × AVDD-0.5125                |
| 42   | 2A   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.5250                  | VDD1→VDD2             | 1.20                              | 2.60                              | 2.5 / 2.7                                      | 5                                   | 2                                      | 600                           | 4                                   | 0                                   | 0.45 × AVDD-0.5250                |
| 43   | 2B   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.5375                  | VDD1→VDD2             | 1.20                              | 2.60                              | 2.5 / 2.7                                      | 5                                   | 3                                      | 600                           | 4                                   | 0                                   | 0.45 × AVDD-0.5375                |
| 44   | 2C   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.5500                  | VDD1→VDD2             | 1.20                              | 2.60                              | 2.5 / 2.7                                      | 5                                   | 4                                      | 600                           | 4                                   | 0                                   | 0.45 × AVDD-0.5500                |
| 45   | 2D   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.5625                  | VDD1→VDD2             | 1.20                              | 2.60                              | 2.5 / 2.7                                      | 5                                   | 5                                      | 600                           | 4                                   | 0                                   | 0.45 × AVDD-0.5625                |
| 46   | 2E   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.5750                  | VDD1→VDD2             | 1.20                              | 2.60                              | 2.5 / 2.7                                      | 5                                   | 0                                      | 600                           | 4                                   | 0                                   | 0.45 × AVDD-0.5750                |
| 47   | 2F   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.5875                  | VDD1→VDD2             | 1.20                              | 2.60                              | 2.5 / 2.7                                      | 5                                   | 0                                      | 600                           | 4                                   | 0                                   | 0.45 × AVDD-0.5875                |
| 48   | 30   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.6000                  | VDD1→VDD2             | 1.25                              | 1.70                              | 2.5 / 2.7                                      | 0                                   | 0                                      | 600                           | 6                                   | 0                                   | 0.45 × AVDD-0.6000                |
| 49   | 31   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.6125                  | VDD1→VDD2             | 1.25                              | 1.75                              | 2.5 / 2.7                                      | 0                                   | 1                                      | 600                           | 6                                   | 5                                   | 0.45 × AVDD-0.6125                |
| 50   | 32   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.6250                  | VDD1→VDD2             | 1.25                              | 1.80                              | 2.5 / 2.7                                      | 0                                   | 2                                      | 600                           | 6                                   | 10                                  | 0.45 × AVDD-0.6250                |
| 51   | 33   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.6375                  | VDD1→VDD2             | 1.25                              | 1.85                              | 2.5 / 2.7                                      | 0                                   | 3                                      | 600                           | 6                                   | 15                                  | 0.45 × AVDD-0.6375                |
| 52   | 34   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.6500                  | VDD1→VDD2             | 1.25                              | 1.90                              | 2.5 / 2.7                                      | 0                                   | 4                                      | 600                           | 6                                   | 20                                  | 0.45 × AVDD-0.6500                |
| 53   | 35   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.6625                  | VDD1→VDD2             | 1.25                              | 2.40                              | 2.5 / 2.7                                      | 0                                   | 5                                      | 600                           | 6                                   | 25                                  | 0.45 × AVDD-0.6625                |
| 54   | 36   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.6750                  | VDD1→VDD2             | 1.25                              | 2.45                              | 2.5 / 2.7                                      | 0                                   | 0                                      | 600                           | 6                                   | 30                                  | 0.45 × AVDD-0.6750                |
| 55   | 37   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.6875                  | VDD1→VDD2             | 1.25                              | 2.50                              | 2.5 / 2.7                                      | 0                                   | 0                                      | 600                           | 6                                   | 35                                  | 0.45 × AVDD-0.6875                |
| 56   | 38   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.7000                  | VDD1→VDD2             | 1.25                              | 2.55                              | 2.5 / 2.7                                      | 0                                   | 0                                      | 600                           | 6                                   | 40                                  | 0.45 × AVDD-0.7000                |
| 57   | 39   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.7125                  | VDD1→VDD2             | 1.25                              | 2.60                              | 2.5 / 2.7                                      | 0                                   | 1                                      | 600                           | 6                                   | 0                                   | 0.45 × AVDD-0.7125                |
| 58   | 3A   | 14.5                              | 26.0                             | -4.0                             | 0.6 × AVDD-0.7250                  | VDD1→VDD2             | 1.25                              | 2.60                              | 2.5 / 2.7                                      | 0                                   | 2                                      | 600                           | 6                                   | 0                                   | 0.45 × AVDD-0.7250                |
| 59   | 3B   | 14.5                              | 26.0                             | -4.1                             | 0.6 × AVDD-0.7375                  | VDD1→VDD2             | 1.25                              | 2.60                              | 2.5 / 2.7                                      | 0                                   | 3                                      | 600                           | 6                                   | 0                                   | 0.45 × AVDD-0.7375                |
| 60   | 3C   | 14.5                              | 26.0                             | -4.2                             | 0.6 × AVDD-0.7500                  | VDD1→VDD2             | 1.25                              | 2.60                              | 2.5 / 2.7                                      | 0                                   | 4                                      | 600                           | 6                                   | 0                                   | 0.45 × AVDD-0.7500                |
| 61   | 3D   | 14.5                              | 26.0                             | -4.3                             | 0.6 × AVDD-0.7625                  | VDD1→VDD2             | 1.25                              | 2.60                              | 2.5 / 2.7                                      | 0                                   | 5                                      | 600                           | 6                                   | 0                                   | 0.45 × AVDD-0.7625                |
| 62   | 3E   | 14.5                              | 26.0                             | -4.4                             | 0.6 × AVDD-0.7750                  | VDD1→VDD2             | 1.25                              | 2.60                              | 2.5 / 2.7                                      | 0                                   | 0                                      | 600                           | 6                                   | 0                                   | 0.45 × AVDD-0.7750                |
| 63   | 3F   | 14.5                              | 26.0                             | -4.5                             | 0.6 × AVDD-0.7875                  | VDD1→VDD2             | 1.25                              | 2.60                              | 2.5 / 2.7                                      | 0                                   | 0                                      | 600                           | 6                                   | 0                                   | 0.45 × AVDD-0.7875                |

## ●Command Table 2

| DATA |      | Register                          |                                  |                                  |                                    |                       |                                   |                                   |                                                |                                     |                                        |                               |                                     |                                     |                                   |
|------|------|-----------------------------------|----------------------------------|----------------------------------|------------------------------------|-----------------------|-----------------------------------|-----------------------------------|------------------------------------------------|-------------------------------------|----------------------------------------|-------------------------------|-------------------------------------|-------------------------------------|-----------------------------------|
|      |      | 01h                               | 02h                              | 03h                              | 04h                                | 05h                   |                                   |                                   | 06h                                            |                                     |                                        | 07h                           |                                     |                                     | 09h                               |
|      |      | AVDD<br>Voltage<br>Setting<br>[V] | VGH<br>Voltage<br>Setting<br>[V] | VGL<br>Voltage<br>Setting<br>[V] | HAVDD<br>Voltage<br>Setting<br>[V] | VDD<br>ON<br>Sequence | VDD2<br>Voltage<br>Setting<br>[V] | VDD1<br>Voltage<br>Setting<br>[V] | DC/DC UVLO<br>Detect/Release<br>Voltage<br>[V] | DELAY1<br>Time<br>Setting<br>[msec] | Discharge<br>Time<br>Setting<br>[msec] | Frequency<br>Setting<br>[kHz] | DELAY3<br>Time<br>Setting<br>[msec] | DELAY2<br>Time<br>Setting<br>[msec] | VCOM<br>Voltage<br>Setting<br>[V] |
| DEC. | HEX. |                                   |                                  |                                  |                                    |                       |                                   |                                   |                                                |                                     |                                        |                               |                                     |                                     |                                   |
| 64   | 40   | 14.5                              | 26.0                             | -4.6                             | 0.6 × AVDD-0.8000                  | VDD1→VDD2             | 1.30                              | 1.70                              | 2.7 / 2.9                                      | 0                                   | 0                                      | 600                           | 8                                   | 0                                   | 0.45 × AVDD-0.8000                |
| 65   | 41   | 14.5                              | 26.0                             | -4.7                             | 0.6 × AVDD-0.8125                  | VDD1→VDD2             | 1.30                              | 1.75                              | 2.7 / 2.9                                      | 0                                   | 1                                      | 600                           | 8                                   | 5                                   | 0.45 × AVDD-0.8125                |
| 66   | 42   | 14.5                              | 26.0                             | -4.8                             | 0.6 × AVDD-0.8250                  | VDD1→VDD2             | 1.30                              | 1.80                              | 2.7 / 2.9                                      | 0                                   | 2                                      | 600                           | 8                                   | 10                                  | 0.45 × AVDD-0.8250                |
| 67   | 43   | 14.5                              | 26.0                             | -4.9                             | 0.6 × AVDD-0.8375                  | VDD1→VDD2             | 1.30                              | 1.85                              | 2.7 / 2.9                                      | 0                                   | 3                                      | 600                           | 8                                   | 15                                  | 0.45 × AVDD-0.8375                |
| 68   | 44   | 14.5                              | 26.0                             | -5.0                             | 0.6 × AVDD-0.8500                  | VDD1→VDD2             | 1.30                              | 1.90                              | 2.7 / 2.9                                      | 0                                   | 4                                      | 600                           | 8                                   | 20                                  | 0.45 × AVDD-0.8500                |
| 69   | 45   | 14.5                              | 26.0                             | -5.1                             | 0.6 × AVDD-0.8625                  | VDD1→VDD2             | 1.30                              | 2.40                              | 2.7 / 2.9                                      | 0                                   | 5                                      | 600                           | 8                                   | 25                                  | 0.45 × AVDD-0.8625                |
| 70   | 46   | 14.5                              | 26.0                             | -5.2                             | 0.6 × AVDD-0.8750                  | VDD1→VDD2             | 1.30                              | 2.45                              | 2.7 / 2.9                                      | 0                                   | 0                                      | 600                           | 8                                   | 30                                  | 0.45 × AVDD-0.8750                |
| 71   | 47   | 14.5                              | 26.0                             | -5.3                             | 0.6 × AVDD-0.8875                  | VDD1→VDD2             | 1.30                              | 2.50                              | 2.7 / 2.9                                      | 0                                   | 0                                      | 600                           | 8                                   | 35                                  | 0.45 × AVDD-0.8875                |
| 72   | 48   | 14.5                              | 26.0                             | -5.4                             | 0.6 × AVDD-0.9000                  | VDD1→VDD2             | 1.30                              | 2.55                              | 2.7 / 2.9                                      | 1                                   | 0                                      | 600                           | 8                                   | 40                                  | 0.45 × AVDD-0.9000                |
| 73   | 49   | 14.5                              | 26.0                             | -5.5                             | 0.6 × AVDD-0.9125                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 1                                   | 1                                      | 600                           | 8                                   | 0                                   | 0.45 × AVDD-0.9125                |
| 74   | 4A   | 14.5                              | 26.0                             | -5.6                             | 0.6 × AVDD-0.9250                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 1                                   | 2                                      | 600                           | 8                                   | 0                                   | 0.45 × AVDD-0.9250                |
| 75   | 4B   | 14.5                              | 26.0                             | -5.7                             | 0.6 × AVDD-0.9375                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 1                                   | 3                                      | 600                           | 8                                   | 0                                   | 0.45 × AVDD-0.9375                |
| 76   | 4C   | 14.5                              | 26.0                             | -5.8                             | 0.6 × AVDD-0.9500                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 1                                   | 4                                      | 600                           | 8                                   | 0                                   | 0.45 × AVDD-0.9500                |
| 77   | 4D   | 14.5                              | 26.0                             | -5.9                             | 0.6 × AVDD-0.9625                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 1                                   | 5                                      | 600                           | 8                                   | 0                                   | 0.45 × AVDD-0.9625                |
| 78   | 4E   | 14.5                              | 26.0                             | -6.0                             | 0.6 × AVDD-0.9750                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 1                                   | 0                                      | 600                           | 8                                   | 0                                   | 0.45 × AVDD-0.9750                |
| 79   | 4F   | 14.5                              | 26.0                             | -6.1                             | 0.6 × AVDD-0.9875                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 1                                   | 0                                      | 600                           | 8                                   | 0                                   | 0.45 × AVDD-0.9875                |
| 80   | 50   | 14.5                              | 26.0                             | -6.2                             | 0.6 × AVDD-1.0000                  | VDD1→VDD2             | 1.30                              | 1.70                              | 2.7 / 2.9                                      | 2                                   | 0                                      | 600                           | 10                                  | 0                                   | 0.45 × AVDD-1.0000                |
| 81   | 51   | 14.5                              | 26.0                             | -6.3                             | 0.6 × AVDD-1.0125                  | VDD1→VDD2             | 1.30                              | 1.75                              | 2.7 / 2.9                                      | 2                                   | 1                                      | 600                           | 10                                  | 5                                   | 0.45 × AVDD-1.0125                |
| 82   | 52   | 14.5                              | 26.0                             | -6.4                             | 0.6 × AVDD-1.0250                  | VDD1→VDD2             | 1.30                              | 1.80                              | 2.7 / 2.9                                      | 2                                   | 2                                      | 600                           | 10                                  | 10                                  | 0.45 × AVDD-1.0250                |
| 83   | 53   | 14.5                              | 26.0                             | -6.5                             | 0.6 × AVDD-1.0375                  | VDD1→VDD2             | 1.30                              | 1.85                              | 2.7 / 2.9                                      | 2                                   | 3                                      | 600                           | 10                                  | 15                                  | 0.45 × AVDD-1.0375                |
| 84   | 54   | 14.5                              | 26.0                             | -6.6                             | 0.6 × AVDD-1.0500                  | VDD1→VDD2             | 1.30                              | 1.90                              | 2.7 / 2.9                                      | 2                                   | 4                                      | 600                           | 10                                  | 20                                  | 0.45 × AVDD-1.0500                |
| 85   | 55   | 14.5                              | 26.0                             | -6.7                             | 0.6 × AVDD-1.0625                  | VDD1→VDD2             | 1.30                              | 2.40                              | 2.7 / 2.9                                      | 2                                   | 5                                      | 600                           | 10                                  | 25                                  | 0.45 × AVDD-1.0625                |
| 86   | 56   | 14.5                              | 26.0                             | -6.8                             | 0.6 × AVDD-1.0750                  | VDD1→VDD2             | 1.30                              | 2.45                              | 2.7 / 2.9                                      | 2                                   | 0                                      | 600                           | 10                                  | 30                                  | 0.45 × AVDD-1.0750                |
| 87   | 57   | 14.5                              | 26.0                             | -6.9                             | 0.6 × AVDD-1.0875                  | VDD1→VDD2             | 1.30                              | 2.50                              | 2.7 / 2.9                                      | 2                                   | 0                                      | 600                           | 10                                  | 35                                  | 0.45 × AVDD-1.0875                |
| 88   | 58   | 14.5                              | 26.0                             | -7.0                             | 0.6 × AVDD-1.1000                  | VDD1→VDD2             | 1.30                              | 2.55                              | 2.7 / 2.9                                      | 3                                   | 0                                      | 600                           | 10                                  | 40                                  | 0.45 × AVDD-1.1000                |
| 89   | 59   | 14.5                              | 26.0                             | -7.1                             | 0.6 × AVDD-1.1125                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 3                                   | 1                                      | 600                           | 10                                  | 0                                   | 0.45 × AVDD-1.1125                |
| 90   | 5A   | 14.5                              | 26.0                             | -7.2                             | 0.6 × AVDD-1.1250                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 3                                   | 2                                      | 600                           | 10                                  | 0                                   | 0.45 × AVDD-1.1250                |
| 91   | 5B   | 14.5                              | 26.0                             | -7.3                             | 0.6 × AVDD-1.1375                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 3                                   | 3                                      | 600                           | 10                                  | 0                                   | 0.45 × AVDD-1.1375                |
| 92   | 5C   | 14.5                              | 26.0                             | -7.4                             | 0.6 × AVDD-1.1500                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 3                                   | 4                                      | 600                           | 10                                  | 0                                   | 0.45 × AVDD-1.1500                |
| 93   | 5D   | 14.5                              | 26.0                             | -7.5                             | 0.6 × AVDD-1.1625                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 3                                   | 5                                      | 600                           | 10                                  | 0                                   | 0.45 × AVDD-1.1625                |
| 94   | 5E   | 14.5                              | 26.0                             | -7.6                             | 0.6 × AVDD-1.1750                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 3                                   | 0                                      | 600                           | 10                                  | 0                                   | 0.45 × AVDD-1.1750                |
| 95   | 5F   | 14.5                              | 26.0                             | -7.7                             | 0.6 × AVDD-1.1875                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 3                                   | 0                                      | 600                           | 10                                  | 0                                   | 0.45 × AVDD-1.1875                |
| 96   | 60   | 14.5                              | 26.0                             | -7.8                             | 0.6 × AVDD-1.2000                  | VDD1→VDD2             | 1.30                              | 1.70                              | 2.7 / 2.9                                      | 4                                   | 0                                      | 600                           | 0                                   | 0                                   | 0.45 × AVDD-1.2000                |
| 97   | 61   | 14.5                              | 26.0                             | -7.9                             | 0.6 × AVDD-1.2125                  | VDD1→VDD2             | 1.30                              | 1.75                              | 2.7 / 2.9                                      | 4                                   | 1                                      | 600                           | 0                                   | 5                                   | 0.45 × AVDD-1.2125                |
| 98   | 62   | 14.5                              | 26.0                             | -8.0                             | 0.6 × AVDD-1.2250                  | VDD1→VDD2             | 1.30                              | 1.80                              | 2.7 / 2.9                                      | 4                                   | 2                                      | 600                           | 0                                   | 10                                  | 0.45 × AVDD-1.2250                |
| 99   | 63   | 14.5                              | 26.0                             | -8.1                             | 0.6 × AVDD-1.2375                  | VDD1→VDD2             | 1.30                              | 1.85                              | 2.7 / 2.9                                      | 4                                   | 3                                      | 600                           | 0                                   | 15                                  | 0.45 × AVDD-1.2375                |
| 100  | 64   | 14.5                              | 26.0                             | -8.2                             | 0.6 × AVDD-1.2500                  | VDD1→VDD2             | 1.30                              | 1.90                              | 2.7 / 2.9                                      | 4                                   | 4                                      | 600                           | 0                                   | 20                                  | 0.45 × AVDD-1.2500                |
| 101  | 65   | 14.5                              | 26.0                             | -8.3                             | 0.6 × AVDD-1.2625                  | VDD1→VDD2             | 1.30                              | 2.40                              | 2.7 / 2.9                                      | 4                                   | 5                                      | 600                           | 0                                   | 25                                  | 0.45 × AVDD-1.2625                |
| 102  | 66   | 14.5                              | 26.0                             | -8.4                             | 0.6 × AVDD-1.2750                  | VDD1→VDD2             | 1.30                              | 2.45                              | 2.7 / 2.9                                      | 4                                   | 0                                      | 600                           | 0                                   | 30                                  | 0.45 × AVDD-1.2750                |
| 103  | 67   | 14.5                              | 26.0                             | -8.5                             | 0.6 × AVDD-1.2875                  | VDD1→VDD2             | 1.30                              | 2.50                              | 2.7 / 2.9                                      | 4                                   | 0                                      | 600                           | 0                                   | 35                                  | 0.45 × AVDD-1.2875                |
| 104  | 68   | 14.5                              | 26.0                             | -8.6                             | 0.6 × AVDD-1.3000                  | VDD1→VDD2             | 1.30                              | 2.55                              | 2.7 / 2.9                                      | 5                                   | 0                                      | 600                           | 0                                   | 40                                  | 0.45 × AVDD-1.3000                |
| 105  | 69   | 14.5                              | 26.0                             | -8.7                             | 0.6 × AVDD-1.3125                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 5                                   | 1                                      | 600                           | 0                                   | 0                                   | 0.45 × AVDD-1.3125                |
| 106  | 6A   | 14.5                              | 26.0                             | -8.8                             | 0.6 × AVDD-1.3250                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 5                                   | 2                                      | 600                           | 0                                   | 0                                   | 0.45 × AVDD-1.3250                |
| 107  | 6B   | 14.5                              | 26.0                             | -8.9                             | 0.6 × AVDD-1.3375                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 5                                   | 3                                      | 600                           | 0                                   | 0                                   | 0.45 × AVDD-1.3375                |
| 108  | 6C   | 14.5                              | 26.0                             | -9.0                             | 0.6 × AVDD-1.3500                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 5                                   | 4                                      | 600                           | 0                                   | 0                                   | 0.45 × AVDD-1.3500                |
| 109  | 6D   | 14.5                              | 26.0                             | -9.1                             | 0.6 × AVDD-1.3625                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 5                                   | 5                                      | 600                           | 0                                   | 0                                   | 0.45 × AVDD-1.3625                |
| 110  | 6E   | 14.5                              | 26.0                             | -9.2                             | 0.6 × AVDD-1.3750                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 5                                   | 0                                      | 600                           | 0                                   | 0                                   | 0.45 × AVDD-1.3750                |
| 111  | 6F   | 14.5                              | 26.0                             | -9.3                             | 0.6 × AVDD-1.3875                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 5                                   | 0                                      | 600                           | 0                                   | 0                                   | 0.45 × AVDD-1.3875                |
| 112  | 70   | 14.4                              | 26.0                             | -9.4                             | 0.6 × AVDD-1.4000                  | VDD1→VDD2             | 1.30                              | 1.70                              | 2.7 / 2.9                                      | 0                                   | 0                                      | 600                           | 0                                   | 0                                   | 0.45 × AVDD-1.4000                |
| 113  | 71   | 14.3                              | 26.0                             | -9.5                             | 0.6 × AVDD-1.4125                  | VDD1→VDD2             | 1.30                              | 1.75                              | 2.7 / 2.9                                      | 0                                   | 1                                      | 600                           | 0                                   | 5                                   | 0.45 × AVDD-1.4125                |
| 114  | 72   | 14.2                              | 26.0                             | -9.5                             | 0.6 × AVDD-1.4250                  | VDD1→VDD2             | 1.30                              | 1.80                              | 2.7 / 2.9                                      | 0                                   | 2                                      | 600                           | 0                                   | 10                                  | 0.45 × AVDD-1.4250                |
| 115  | 73   | 14.1                              | 26.0                             | -9.5                             | 0.6 × AVDD-1.4375                  | VDD1→VDD2             | 1.30                              | 1.85                              | 2.7 / 2.9                                      | 0                                   | 3                                      | 600                           | 0                                   | 15                                  | 0.45 × AVDD-1.4375                |
| 116  | 74   | 14.0                              | 26.0                             | -9.5                             | 0.6 × AVDD-1.4500                  | VDD1→VDD2             | 1.30                              | 1.90                              | 2.7 / 2.9                                      | 0                                   | 4                                      | 600                           | 0                                   | 20                                  | 0.45 × AVDD-1.4500                |
| 117  | 75   | 13.9                              | 26.0                             | -9.5                             | 0.6 × AVDD-1.4625                  | VDD1→VDD2             | 1.30                              | 2.40                              | 2.7 / 2.9                                      | 0                                   | 5                                      | 600                           | 0                                   | 25                                  | 0.45 × AVDD-1.4625                |
| 118  | 76   | 13.8                              | 26.0                             | -9.5                             | 0.6 × AVDD-1.4750                  | VDD1→VDD2             | 1.30                              | 2.45                              | 2.7 / 2.9                                      | 0                                   | 0                                      | 600                           | 0                                   | 30                                  | 0.45 × AVDD-1.4750                |
| 119  | 77   | 13.7                              | 26.0                             | -9.5                             | 0.6 × AVDD-1.4875                  | VDD1→VDD2             | 1.30                              | 2.50                              | 2.7 / 2.9                                      | 0                                   | 0                                      | 600                           | 0                                   | 35                                  | 0.45 × AVDD-1.4875                |
| 120  | 78   | 13.6                              | 26.0                             | -9.5                             | 0.6 × AVDD-1.5000                  | VDD1→VDD2             | 1.30                              | 2.55                              | 2.7 / 2.9                                      | 0                                   | 0                                      | 600                           | 0                                   | 40                                  | 0.45 × AVDD-1.5000                |
| 121  | 79   | 13.5                              | 26.0                             | -9.5                             | 0.6 × AVDD-1.5125                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 0                                   | 1                                      | 600                           | 0                                   | 0                                   | 0.45 × AVDD-1.5125                |
| 122  | 7A   | 13.4                              | 26.0                             | -9.5                             | 0.6 × AVDD-1.5250                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 0                                   | 2                                      | 600                           | 0                                   | 0                                   | 0.45 × AVDD-1.5250                |
| 123  | 7B   | 13.3                              | 26.0                             | -9.5                             | 0.6 × AVDD-1.5375                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 0                                   | 3                                      | 600                           | 0                                   | 0                                   | 0.45 × AVDD-1.5375                |
| 124  | 7C   | 13.2                              | 26.0                             | -9.5                             | 0.6 × AVDD-1.5500                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 0                                   | 4                                      | 600                           | 0                                   | 0                                   | 0.45 × AVDD-1.5500                |
| 125  | 7D   | 13.1                              | 26.0                             | -9.5                             | 0.6 × AVDD-1.5625                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 0                                   | 5                                      | 600                           | 0                                   | 0                                   | 0.45 × AVDD-1.5625                |
| 126  | 7E   | 13.0                              | 26.0                             | -9.5                             | 0.6 × AVDD-1.5750                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 0                                   | 0                                      | 600                           | 0                                   | 0                                   | 0.45 × AVDD-1.5750                |
| 127  | 7F   | 12.9                              | 25.8                             | -9.5                             | 0.6 × AVDD-1.5875                  | VDD1→VDD2             | 1.30                              | 2.60                              | 2.7 / 2.9                                      | 0                                   | 0                                      | 600                           | 0                                   | 0                                   | 0.45 × AVDD-1.5875                |

## ●Command Table 3

| DATA |      | Register                          |                                  |                                  |                                    |                       |                                   |                                   |                                                |                                     |                                        |                               |                                     |                                     |                                   |
|------|------|-----------------------------------|----------------------------------|----------------------------------|------------------------------------|-----------------------|-----------------------------------|-----------------------------------|------------------------------------------------|-------------------------------------|----------------------------------------|-------------------------------|-------------------------------------|-------------------------------------|-----------------------------------|
|      |      | 01h                               | 02h                              | 03h                              | 04h                                | 05h                   |                                   |                                   | 06h                                            |                                     |                                        | 07h                           |                                     | 09h                                 |                                   |
|      |      | AVDD<br>Voltage<br>Setting<br>[V] | VGH<br>Voltage<br>Setting<br>[V] | VGL<br>Voltage<br>Setting<br>[V] | HAVDD<br>Voltage<br>Setting<br>[V] | VDD<br>ON<br>Sequence | VDD2<br>Voltage<br>Setting<br>[V] | VDD1<br>Voltage<br>Setting<br>[V] | DC/DC UVLO<br>Detect/Release<br>Voltage<br>[V] | DELAY1<br>Time<br>Setting<br>[msec] | Discharge<br>Time<br>Setting<br>[msec] | Frequency<br>Setting<br>[kHz] | DELAY3<br>Time<br>Setting<br>[msec] | DELAY2<br>Time<br>Setting<br>[msec] | VCOM<br>Voltage<br>Setting<br>[V] |
| DEC. | HEX. |                                   |                                  |                                  |                                    |                       |                                   |                                   |                                                |                                     |                                        |                               |                                     |                                     |                                   |
| 128  | 80   | 12.8                              | 25.6                             | -9.5                             | 0.6 × AVDD-1.6000                  | VDD2→VDD1             | 1.10                              | 1.70                              | 2.9 / 3.1                                      | 0                                   | 0                                      | 1200                          | 0                                   | 0                                   | 0.45 × AVDD-1.6000                |
| 129  | 81   | 12.7                              | 25.4                             | -9.5                             | 0.6 × AVDD-1.6125                  | VDD2→VDD1             | 1.10                              | 1.75                              | 2.9 / 3.1                                      | 0                                   | 1                                      | 1200                          | 0                                   | 5                                   | 0.45 × AVDD-1.6125                |
| 130  | 82   | 12.6                              | 25.2                             | -9.5                             | 0.6 × AVDD-1.6250                  | VDD2→VDD1             | 1.10                              | 1.80                              | 2.9 / 3.1                                      | 0                                   | 2                                      | 1200                          | 0                                   | 10                                  | 0.45 × AVDD-1.6250                |
| 131  | 83   | 12.5                              | 25.0                             | -9.5                             | 0.6 × AVDD-1.6375                  | VDD2→VDD1             | 1.10                              | 1.85                              | 2.9 / 3.1                                      | 0                                   | 3                                      | 1200                          | 0                                   | 15                                  | 0.45 × AVDD-1.6375                |
| 132  | 84   | 12.4                              | 24.8                             | -9.5                             | 0.6 × AVDD-1.6500                  | VDD2→VDD1             | 1.10                              | 1.90                              | 2.9 / 3.1                                      | 0                                   | 4                                      | 1200                          | 0                                   | 20                                  | 0.45 × AVDD-1.6500                |
| 133  | 85   | 12.3                              | 24.6                             | -9.5                             | 0.6 × AVDD-1.6625                  | VDD2→VDD1             | 1.10                              | 2.40                              | 2.9 / 3.1                                      | 0                                   | 5                                      | 1200                          | 0                                   | 25                                  | 0.45 × AVDD-1.6625                |
| 134  | 86   | 12.2                              | 24.4                             | -9.5                             | 0.6 × AVDD-1.6750                  | VDD2→VDD1             | 1.10                              | 2.45                              | 2.9 / 3.1                                      | 0                                   | 0                                      | 1200                          | 0                                   | 30                                  | 0.45 × AVDD-1.6750                |
| 135  | 87   | 12.1                              | 24.2                             | -9.5                             | 0.6 × AVDD-1.6875                  | VDD2→VDD1             | 1.10                              | 2.50                              | 2.9 / 3.1                                      | 0                                   | 0                                      | 1200                          | 0                                   | 35                                  | 0.45 × AVDD-1.6875                |
| 136  | 88   | 12.0                              | 24.0                             | -9.5                             | 0.6 × AVDD-1.7000                  | VDD2→VDD1             | 1.10                              | 2.55                              | 2.9 / 3.1                                      | 1                                   | 0                                      | 1200                          | 0                                   | 40                                  | 0.45 × AVDD-1.7000                |
| 137  | 89   | 11.9                              | 23.8                             | -9.5                             | 0.6 × AVDD-1.7125                  | VDD2→VDD1             | 1.10                              | 2.60                              | 2.9 / 3.1                                      | 1                                   | 1                                      | 1200                          | 0                                   | 0                                   | 0.45 × AVDD-1.7125                |
| 138  | 8A   | 11.8                              | 23.6                             | -9.5                             | 0.6 × AVDD-1.7250                  | VDD2→VDD1             | 1.10                              | 2.60                              | 2.9 / 3.1                                      | 1                                   | 2                                      | 1200                          | 0                                   | 0                                   | 0.45 × AVDD-1.7250                |
| 139  | 8B   | 11.7                              | 23.4                             | -9.5                             | 0.6 × AVDD-1.7375                  | VDD2→VDD1             | 1.10                              | 2.60                              | 2.9 / 3.1                                      | 1                                   | 3                                      | 1200                          | 0                                   | 0                                   | 0.45 × AVDD-1.7375                |
| 140  | 8C   | 11.6                              | 23.2                             | -9.5                             | 0.6 × AVDD-1.7500                  | VDD2→VDD1             | 1.10                              | 2.60                              | 2.9 / 3.1                                      | 1                                   | 4                                      | 1200                          | 0                                   | 0                                   | 0.45 × AVDD-1.7500                |
| 141  | 8D   | 11.5                              | 23.0                             | -9.5                             | 0.6 × AVDD-1.7625                  | VDD2→VDD1             | 1.10                              | 2.60                              | 2.9 / 3.1                                      | 1                                   | 5                                      | 1200                          | 0                                   | 0                                   | 0.45 × AVDD-1.7625                |
| 142  | 8E   | 11.4                              | 22.8                             | -9.5                             | 0.6 × AVDD-1.7750                  | VDD2→VDD1             | 1.10                              | 2.60                              | 2.9 / 3.1                                      | 1                                   | 0                                      | 1200                          | 0                                   | 0                                   | 0.45 × AVDD-1.7750                |
| 143  | 8F   | 11.3                              | 22.6                             | -9.5                             | 0.6 × AVDD-1.7875                  | VDD2→VDD1             | 1.10                              | 2.60                              | 2.9 / 3.1                                      | 1                                   | 0                                      | 1200                          | 0                                   | 0                                   | 0.45 × AVDD-1.7875                |
| 144  | 90   | 11.2                              | 22.4                             | -9.5                             | 0.6 × AVDD-1.8000                  | VDD2→VDD1             | 1.15                              | 1.70                              | 2.9 / 3.1                                      | 2                                   | 0                                      | 1200                          | 2                                   | 0                                   | 0.45 × AVDD-1.8000                |
| 145  | 91   | 11.1                              | 22.2                             | -9.5                             | 0.6 × AVDD-1.8125                  | VDD2→VDD1             | 1.15                              | 1.75                              | 2.9 / 3.1                                      | 2                                   | 1                                      | 1200                          | 2                                   | 5                                   | 0.45 × AVDD-1.8125                |
| 146  | 92   | 11.0                              | 22.0                             | -9.5                             | 0.6 × AVDD-1.8250                  | VDD2→VDD1             | 1.15                              | 1.80                              | 2.9 / 3.1                                      | 2                                   | 2                                      | 1200                          | 2                                   | 10                                  | 0.45 × AVDD-1.8250                |
| 147  | 93   | 10.9                              | 21.8                             | -9.5                             | 0.6 × AVDD-1.8375                  | VDD2→VDD1             | 1.15                              | 1.85                              | 2.9 / 3.1                                      | 2                                   | 3                                      | 1200                          | 2                                   | 15                                  | 0.45 × AVDD-1.8375                |
| 148  | 94   | 10.8                              | 21.6                             | -9.5                             | 0.6 × AVDD-1.8500                  | VDD2→VDD1             | 1.15                              | 1.90                              | 2.9 / 3.1                                      | 2                                   | 4                                      | 1200                          | 2                                   | 20                                  | 0.45 × AVDD-1.8500                |
| 149  | 95   | 10.7                              | 21.4                             | -9.5                             | 0.6 × AVDD-1.8625                  | VDD2→VDD1             | 1.15                              | 2.40                              | 2.9 / 3.1                                      | 2                                   | 5                                      | 1200                          | 2                                   | 25                                  | 0.45 × AVDD-1.8625                |
| 150  | 96   | 10.6                              | 21.2                             | -9.5                             | 0.6 × AVDD-1.8750                  | VDD2→VDD1             | 1.15                              | 2.45                              | 2.9 / 3.1                                      | 2                                   | 0                                      | 1200                          | 2                                   | 30                                  | 0.45 × AVDD-1.8750                |
| 151  | 97   | 10.5                              | 21.0                             | -9.5                             | 0.6 × AVDD-1.8875                  | VDD2→VDD1             | 1.15                              | 2.50                              | 2.9 / 3.1                                      | 2                                   | 0                                      | 1200                          | 2                                   | 35                                  | 0.45 × AVDD-1.8875                |
| 152  | 98   | 10.4                              | 20.8                             | -9.5                             | 0.6 × AVDD-1.9000                  | VDD2→VDD1             | 1.15                              | 2.55                              | 2.9 / 3.1                                      | 3                                   | 0                                      | 1200                          | 2                                   | 40                                  | 0.45 × AVDD-1.9000                |
| 153  | 99   | 10.3                              | 20.6                             | -9.5                             | 0.6 × AVDD-1.9125                  | VDD2→VDD1             | 1.15                              | 2.60                              | 2.9 / 3.1                                      | 3                                   | 1                                      | 1200                          | 2                                   | 0                                   | 0.45 × AVDD-1.9125                |
| 154  | 9A   | 10.2                              | 20.4                             | -9.5                             | 0.6 × AVDD-1.9250                  | VDD2→VDD1             | 1.15                              | 2.60                              | 2.9 / 3.1                                      | 3                                   | 2                                      | 1200                          | 2                                   | 0                                   | 0.45 × AVDD-1.9250                |
| 155  | 9B   | 10.1                              | 20.2                             | -9.5                             | 0.6 × AVDD-1.9375                  | VDD2→VDD1             | 1.15                              | 2.60                              | 2.9 / 3.1                                      | 3                                   | 3                                      | 1200                          | 2                                   | 0                                   | 0.45 × AVDD-1.9375                |
| 156  | 9C   | 10.0                              | 20.0                             | -9.5                             | 0.6 × AVDD-1.9500                  | VDD2→VDD1             | 1.15                              | 2.60                              | 2.9 / 3.1                                      | 3                                   | 4                                      | 1200                          | 2                                   | 0                                   | 0.45 × AVDD-1.9500                |
| 157  | 9D   | 9.9                               | 19.8                             | -9.5                             | 0.6 × AVDD-1.9625                  | VDD2→VDD1             | 1.15                              | 2.60                              | 2.9 / 3.1                                      | 3                                   | 5                                      | 1200                          | 2                                   | 0                                   | 0.45 × AVDD-1.9625                |
| 158  | 9E   | 9.8                               | 19.6                             | -9.5                             | 0.6 × AVDD-1.9750                  | VDD2→VDD1             | 1.15                              | 2.60                              | 2.9 / 3.1                                      | 3                                   | 0                                      | 1200                          | 2                                   | 0                                   | 0.45 × AVDD-1.9750                |
| 159  | 9F   | 9.7                               | 19.4                             | -9.5                             | 0.6 × AVDD-1.9875                  | VDD2→VDD1             | 1.15                              | 2.60                              | 2.9 / 3.1                                      | 3                                   | 0                                      | 1200                          | 2                                   | 0                                   | 0.45 × AVDD-1.9875                |
| 160  | 9A   | 9.6                               | 19.2                             | -9.5                             | 0.6 × AVDD-2.0000                  | VDD2→VDD1             | 1.20                              | 1.70                              | 2.9 / 3.1                                      | 4                                   | 0                                      | 1200                          | 4                                   | 0                                   | 0.45 × AVDD-2.0000                |
| 161  | A1   | 9.5                               | 19.0                             | -9.5                             | 0.6 × AVDD-2.0125                  | VDD2→VDD1             | 1.20                              | 1.75                              | 2.9 / 3.1                                      | 4                                   | 1                                      | 1200                          | 4                                   | 5                                   | 0.45 × AVDD-2.0125                |
| 162  | A2   | 9.4                               | 18.8                             | -9.5                             | 0.6 × AVDD-2.0250                  | VDD2→VDD1             | 1.20                              | 1.80                              | 2.9 / 3.1                                      | 4                                   | 2                                      | 1200                          | 4                                   | 10                                  | 0.45 × AVDD-2.0250                |
| 163  | A3   | 9.3                               | 18.6                             | -9.5                             | 0.6 × AVDD-2.0375                  | VDD2→VDD1             | 1.20                              | 1.85                              | 2.9 / 3.1                                      | 4                                   | 3                                      | 1200                          | 4                                   | 15                                  | 0.45 × AVDD-2.0375                |
| 164  | A4   | 9.2                               | 18.4                             | -9.5                             | 0.6 × AVDD-2.0500                  | VDD2→VDD1             | 1.20                              | 1.90                              | 2.9 / 3.1                                      | 4                                   | 4                                      | 1200                          | 4                                   | 20                                  | 0.45 × AVDD-2.0500                |
| 165  | A5   | 9.1                               | 18.2                             | -9.5                             | 0.6 × AVDD-2.0625                  | VDD2→VDD1             | 1.20                              | 2.40                              | 2.9 / 3.1                                      | 4                                   | 5                                      | 1200                          | 4                                   | 25                                  | 0.45 × AVDD-2.0625                |
| 166  | A6   | 9.0                               | 18.0                             | -9.5                             | 0.6 × AVDD-2.0750                  | VDD2→VDD1             | 1.20                              | 2.45                              | 2.9 / 3.1                                      | 4                                   | 0                                      | 1200                          | 4                                   | 30                                  | 0.45 × AVDD-2.0750                |
| 167  | A7   | 8.9                               | 17.8                             | -9.5                             | 0.6 × AVDD-2.0875                  | VDD2→VDD1             | 1.20                              | 2.50                              | 2.9 / 3.1                                      | 4                                   | 0                                      | 1200                          | 4                                   | 35                                  | 0.45 × AVDD-2.0875                |
| 168  | A8   | 8.8                               | 17.6                             | -9.5                             | 0.6 × AVDD-2.1000                  | VDD2→VDD1             | 1.20                              | 2.55                              | 2.9 / 3.1                                      | 5                                   | 0                                      | 1200                          | 4                                   | 40                                  | 0.45 × AVDD-2.1000                |
| 169  | A9   | 8.7                               | 17.4                             | -9.5                             | 0.6 × AVDD-2.1125                  | VDD2→VDD1             | 1.20                              | 2.60                              | 2.9 / 3.1                                      | 5                                   | 1                                      | 1200                          | 4                                   | 0                                   | 0.45 × AVDD-2.1125                |
| 170  | AA   | 8.6                               | 17.2                             | -9.5                             | 0.6 × AVDD-2.1250                  | VDD2→VDD1             | 1.20                              | 2.60                              | 2.9 / 3.1                                      | 5                                   | 2                                      | 1200                          | 4                                   | 0                                   | 0.45 × AVDD-2.1250                |
| 171  | AB   | 8.5                               | 17.0                             | -9.5                             | 0.6 × AVDD-2.1375                  | VDD2→VDD1             | 1.20                              | 2.60                              | 2.9 / 3.1                                      | 5                                   | 3                                      | 1200                          | 4                                   | 0                                   | 0.45 × AVDD-2.1375                |
| 172  | AC   | 8.4                               | 16.8                             | -9.5                             | 0.6 × AVDD-2.1500                  | VDD2→VDD1             | 1.20                              | 2.60                              | 2.9 / 3.1                                      | 5                                   | 4                                      | 1200                          | 4                                   | 0                                   | 0.45 × AVDD-2.1500                |
| 173  | AD   | 8.3                               | 16.6                             | -9.5                             | 0.6 × AVDD-2.1625                  | VDD2→VDD1             | 1.20                              | 2.60                              | 2.9 / 3.1                                      | 5                                   | 5                                      | 1200                          | 4                                   | 0                                   | 0.45 × AVDD-2.1625                |
| 174  | AE   | 8.2                               | 16.4                             | -9.5                             | 0.6 × AVDD-2.1750                  | VDD2→VDD1             | 1.20                              | 2.60                              | 2.9 / 3.1                                      | 5                                   | 0                                      | 1200                          | 4                                   | 0                                   | 0.45 × AVDD-2.1750                |
| 175  | AF   | 8.1                               | 16.2                             | -9.5                             | 0.6 × AVDD-2.1875                  | VDD2→VDD1             | 1.20                              | 2.60                              | 2.9 / 3.1                                      | 5                                   | 0                                      | 1200                          | 4                                   | 0                                   | 0.45 × AVDD-2.1875                |
| 176  | B0   | 8.0                               | 16.0                             | -9.5                             | 0.6 × AVDD-2.2000                  | VDD2→VDD1             | 1.25                              | 1.70                              | 2.9 / 3.1                                      | 0                                   | 0                                      | 1200                          | 6                                   | 0                                   | 0.45 × AVDD-2.2000                |
| 177  | B1   | 8.0                               | 15.8                             | -9.5                             | 0.6 × AVDD-2.2125                  | VDD2→VDD1             | 1.25                              | 1.75                              | 2.9 / 3.1                                      | 0                                   | 1                                      | 1200                          | 6                                   | 5                                   | 0.45 × AVDD-2.2125                |
| 178  | B2   | 8.0                               | 15.6                             | -9.5                             | 0.6 × AVDD-2.2250                  | VDD2→VDD1             | 1.25                              | 1.80                              | 2.9 / 3.1                                      | 0                                   | 2                                      | 1200                          | 6                                   | 10                                  | 0.45 × AVDD-2.2250                |
| 179  | B3   | 8.0                               | 15.4                             | -9.5                             | 0.6 × AVDD-2.2375                  | VDD2→VDD1             | 1.25                              | 1.85                              | 2.9 / 3.1                                      | 0                                   | 3                                      | 1200                          | 6                                   | 15                                  | 0.45 × AVDD-2.2375                |
| 180  | B4   | 8.0                               | 15.2                             | -9.5                             | 0.6 × AVDD-2.2500                  | VDD2→VDD1             | 1.25                              | 1.90                              | 2.9 / 3.1                                      | 0                                   | 4                                      | 1200                          | 6                                   | 20                                  | 0.45 × AVDD-2.2500                |
| 181  | B5   | 8.0                               | 15.0                             | -9.5                             | 0.6 × AVDD-2.2625                  | VDD2→VDD1             | 1.25                              | 2.40                              | 2.9 / 3.1                                      | 0                                   | 5                                      | 1200                          | 6                                   | 25                                  | 0.45 × AVDD-2.2625                |
| 182  | B6   | 8.0                               | 14.8                             | -9.5                             | 0.6 × AVDD-2.2750                  | VDD2→VDD1             | 1.25                              | 2.45                              | 2.9 / 3.1                                      | 0                                   | 0                                      | 1200                          | 6                                   | 30                                  | 0.45 × AVDD-2.2750                |
| 183  | B7   | 8.0                               | 14.6                             | -9.5                             | 0.6 × AVDD-2.2875                  | VDD2→VDD1             | 1.25                              | 2.50                              | 2.9 / 3.1                                      | 0                                   | 0                                      | 1200                          | 6                                   | 35                                  | 0.45 × AVDD-2.2875                |
| 184  | B8   | 8.0                               | 14.4                             | -9.5                             | 0.6 × AVDD-2.3000                  | VDD2→VDD1             | 1.25                              | 2.55                              | 2.9 / 3.1                                      | 0                                   | 0                                      | 1200                          | 6                                   | 40                                  | 0.45 × AVDD-2.3000                |
| 185  | B9   | 8.0                               | 14.2                             | -9.5                             | 0.6 × AVDD-2.3125                  | VDD2→VDD1             | 1.25                              | 2.60                              | 2.9 / 3.1                                      | 0                                   | 1                                      | 1200                          | 6                                   | 0                                   | 0.45 × AVDD-2.3125                |
| 186  | BA   | 8.0                               | 14.0                             | -9.5                             | 0.6 × AVDD-2.3250                  | VDD2→VDD1             | 1.25                              | 2.60                              | 2.9 / 3.1                                      | 0                                   | 2                                      | 1200                          | 6                                   | 0                                   | 0.45 × AVDD-2.3250                |
| 187  | BB   | 8.0                               | 13.8                             | -9.5                             | 0.6 × AVDD-2.3375                  | VDD2→VDD1             | 1.25                              | 2.60                              | 2.9 / 3.1                                      | 0                                   | 3                                      | 1200                          | 6                                   | 0                                   | 0.45 × AVDD-2.3375                |
| 188  | BC   | 8.0                               | 13.6                             | -9.5                             | 0.6 × AVDD-2.3500                  | VDD2→VDD1             | 1.25                              | 2.60                              | 2.9 / 3.1                                      | 0                                   | 4                                      | 1200                          | 6                                   | 0                                   | 0.45 × AVDD-2.3500                |
| 189  | BD   | 8.0                               | 13.4                             | -9.5                             | 0.6 × AVDD-2.3625                  | VDD2→VDD1             | 1.25                              | 2.60                              | 2.9 / 3.1                                      | 0                                   | 5                                      | 1200                          | 6                                   | 0                                   | 0.45 × AVDD-2.3625                |
| 190  | BE   | 8.0                               | 13.2                             | -9.5                             | 0.6 × AVDD-2.3750                  | VDD2→VDD1             | 1.25                              | 2.60                              | 2.9 / 3.1                                      | 0                                   | 0                                      | 1200                          | 6                                   | 0                                   | 0.45 × AVDD-2.3750                |
| 191  | BF   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.3875                  | VDD2→VDD1             | 1.25                              | 2.60                              | 2.9 / 3.1                                      | 0                                   | 0                                      | 1200                          | 6                                   | 0                                   | 0.45 × AVDD-2.3875                |

## ●Command Table 4

| DATA |      | Register                          |                                  |                                  |                                    |                       |                                   |                                   |                                                |                                     |                                        |                               |                                     |                                     |                                   |
|------|------|-----------------------------------|----------------------------------|----------------------------------|------------------------------------|-----------------------|-----------------------------------|-----------------------------------|------------------------------------------------|-------------------------------------|----------------------------------------|-------------------------------|-------------------------------------|-------------------------------------|-----------------------------------|
|      |      | 01h                               | 02h                              | 03h                              | 04h                                | 05h                   |                                   |                                   | 06h                                            |                                     |                                        | 07h                           |                                     |                                     | 09h                               |
|      |      | AVDD<br>Voltage<br>Setting<br>[V] | VGH<br>Voltage<br>Setting<br>[V] | VGL<br>Voltage<br>Setting<br>[V] | HAVDD<br>Voltage<br>Setting<br>[V] | VDD<br>ON<br>Sequence | VDD2<br>Voltage<br>Setting<br>[V] | VDD1<br>Voltage<br>Setting<br>[V] | DC/DC UVLO<br>Detect/Release<br>Voltage<br>[V] | DELAY1<br>Time<br>Setting<br>[msec] | Discharge<br>Time<br>Setting<br>[msec] | Frequency<br>Setting<br>[kHz] | DELAY3<br>Time<br>Setting<br>[msec] | DELAY2<br>Time<br>Setting<br>[msec] | VCOM<br>Voltage<br>Setting<br>[V] |
| DEC. | HEX. |                                   |                                  |                                  |                                    |                       |                                   |                                   |                                                |                                     |                                        |                               |                                     |                                     |                                   |
| 192  | C0   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.4000                  | VDD2→VDD1             | 1.30                              | 1.70                              | 3.1 / 3.3                                      | 0                                   | 0                                      | 1200                          | 8                                   | 0                                   | 0.45 × AVDD-2.4000                |
| 193  | C1   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.4125                  | VDD2→VDD1             | 1.30                              | 1.75                              | 3.1 / 3.3                                      | 0                                   | 1                                      | 1200                          | 8                                   | 5                                   | 0.45 × AVDD-2.4125                |
| 194  | C2   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.4250                  | VDD2→VDD1             | 1.30                              | 1.80                              | 3.1 / 3.3                                      | 0                                   | 2                                      | 1200                          | 8                                   | 10                                  | 0.45 × AVDD-2.4250                |
| 195  | C3   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.4375                  | VDD2→VDD1             | 1.30                              | 1.85                              | 3.1 / 3.3                                      | 0                                   | 3                                      | 1200                          | 8                                   | 15                                  | 0.45 × AVDD-2.4375                |
| 196  | C4   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.4500                  | VDD2→VDD1             | 1.30                              | 1.90                              | 3.1 / 3.3                                      | 0                                   | 4                                      | 1200                          | 8                                   | 20                                  | 0.45 × AVDD-2.4500                |
| 197  | C5   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.4625                  | VDD2→VDD1             | 1.30                              | 2.40                              | 3.1 / 3.3                                      | 0                                   | 5                                      | 1200                          | 8                                   | 25                                  | 0.45 × AVDD-2.4625                |
| 198  | C6   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.4750                  | VDD2→VDD1             | 1.30                              | 2.45                              | 3.1 / 3.3                                      | 0                                   | 0                                      | 1200                          | 8                                   | 30                                  | 0.45 × AVDD-2.4750                |
| 199  | C7   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.4875                  | VDD2→VDD1             | 1.30                              | 2.50                              | 3.1 / 3.3                                      | 0                                   | 0                                      | 1200                          | 8                                   | 35                                  | 0.45 × AVDD-2.4875                |
| 200  | C8   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.5000                  | VDD2→VDD1             | 1.30                              | 2.55                              | 3.1 / 3.3                                      | 1                                   | 0                                      | 1200                          | 8                                   | 40                                  | 0.45 × AVDD-2.5000                |
| 201  | C9   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.5125                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 1                                   | 1                                      | 1200                          | 8                                   | 0                                   | 0.45 × AVDD-2.5125                |
| 202  | CA   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.5250                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 1                                   | 2                                      | 1200                          | 8                                   | 0                                   | 0.45 × AVDD-2.5250                |
| 203  | CB   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.5375                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 1                                   | 3                                      | 1200                          | 8                                   | 0                                   | 0.45 × AVDD-2.5375                |
| 204  | CC   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.5500                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 1                                   | 4                                      | 1200                          | 8                                   | 0                                   | 0.45 × AVDD-2.5500                |
| 205  | CD   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.5625                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 1                                   | 5                                      | 1200                          | 8                                   | 0                                   | 0.45 × AVDD-2.5625                |
| 206  | CE   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.5750                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 1                                   | 0                                      | 1200                          | 8                                   | 0                                   | 0.45 × AVDD-2.5750                |
| 207  | CF   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.5875                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 1                                   | 0                                      | 1200                          | 8                                   | 0                                   | 0.45 × AVDD-2.5875                |
| 208  | D0   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.6000                  | VDD2→VDD1             | 1.30                              | 1.70                              | 3.1 / 3.3                                      | 2                                   | 0                                      | 1200                          | 10                                  | 0                                   | 0.45 × AVDD-2.6000                |
| 209  | D1   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.6125                  | VDD2→VDD1             | 1.30                              | 1.75                              | 3.1 / 3.3                                      | 2                                   | 1                                      | 1200                          | 10                                  | 5                                   | 0.45 × AVDD-2.6125                |
| 210  | D2   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.6250                  | VDD2→VDD1             | 1.30                              | 1.80                              | 3.1 / 3.3                                      | 2                                   | 2                                      | 1200                          | 10                                  | 10                                  | 0.45 × AVDD-2.6250                |
| 211  | D3   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.6375                  | VDD2→VDD1             | 1.30                              | 1.85                              | 3.1 / 3.3                                      | 2                                   | 3                                      | 1200                          | 10                                  | 15                                  | 0.45 × AVDD-2.6375                |
| 212  | D4   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.6500                  | VDD2→VDD1             | 1.30                              | 1.90                              | 3.1 / 3.3                                      | 2                                   | 4                                      | 1200                          | 10                                  | 20                                  | 0.45 × AVDD-2.6500                |
| 213  | D5   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.6625                  | VDD2→VDD1             | 1.30                              | 2.40                              | 3.1 / 3.3                                      | 2                                   | 5                                      | 1200                          | 10                                  | 25                                  | 0.45 × AVDD-2.6625                |
| 214  | D6   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.6750                  | VDD2→VDD1             | 1.30                              | 2.45                              | 3.1 / 3.3                                      | 2                                   | 0                                      | 1200                          | 10                                  | 30                                  | 0.45 × AVDD-2.6750                |
| 215  | D7   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.6875                  | VDD2→VDD1             | 1.30                              | 2.50                              | 3.1 / 3.3                                      | 2                                   | 0                                      | 1200                          | 10                                  | 35                                  | 0.45 × AVDD-2.6875                |
| 216  | D8   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.7000                  | VDD2→VDD1             | 1.30                              | 2.55                              | 3.1 / 3.3                                      | 3                                   | 0                                      | 1200                          | 10                                  | 40                                  | 0.45 × AVDD-2.7000                |
| 217  | D9   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.7125                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 3                                   | 1                                      | 1200                          | 10                                  | 0                                   | 0.45 × AVDD-2.7125                |
| 218  | DA   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.7250                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 3                                   | 2                                      | 1200                          | 10                                  | 0                                   | 0.45 × AVDD-2.7250                |
| 219  | DB   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.7375                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 3                                   | 3                                      | 1200                          | 10                                  | 0                                   | 0.45 × AVDD-2.7375                |
| 220  | DC   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.7500                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 3                                   | 4                                      | 1200                          | 10                                  | 0                                   | 0.45 × AVDD-2.7500                |
| 221  | DD   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.7625                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 3                                   | 5                                      | 1200                          | 10                                  | 0                                   | 0.45 × AVDD-2.7625                |
| 222  | DE   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.7750                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 3                                   | 0                                      | 1200                          | 10                                  | 0                                   | 0.45 × AVDD-2.7750                |
| 223  | DF   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.7875                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 3                                   | 0                                      | 1200                          | 10                                  | 0                                   | 0.45 × AVDD-2.7875                |
| 224  | E0   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.8000                  | VDD2→VDD1             | 1.30                              | 1.70                              | 3.1 / 3.3                                      | 4                                   | 0                                      | 1200                          | 0                                   | 0                                   | 0.45 × AVDD-2.8000                |
| 225  | E1   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.8125                  | VDD2→VDD1             | 1.30                              | 1.75                              | 3.1 / 3.3                                      | 4                                   | 1                                      | 1200                          | 0                                   | 5                                   | 0.45 × AVDD-2.8125                |
| 226  | E2   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.8250                  | VDD2→VDD1             | 1.30                              | 1.80                              | 3.1 / 3.3                                      | 4                                   | 2                                      | 1200                          | 0                                   | 10                                  | 0.45 × AVDD-2.8250                |
| 227  | E3   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.8375                  | VDD2→VDD1             | 1.30                              | 1.85                              | 3.1 / 3.3                                      | 4                                   | 3                                      | 1200                          | 0                                   | 15                                  | 0.45 × AVDD-2.8375                |
| 228  | E4   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.8500                  | VDD2→VDD1             | 1.30                              | 1.90                              | 3.1 / 3.3                                      | 4                                   | 4                                      | 1200                          | 0                                   | 20                                  | 0.45 × AVDD-2.8500                |
| 229  | E5   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.8625                  | VDD2→VDD1             | 1.30                              | 2.40                              | 3.1 / 3.3                                      | 4                                   | 5                                      | 1200                          | 0                                   | 25                                  | 0.45 × AVDD-2.8625                |
| 230  | E6   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.8750                  | VDD2→VDD1             | 1.30                              | 2.45                              | 3.1 / 3.3                                      | 4                                   | 0                                      | 1200                          | 0                                   | 30                                  | 0.45 × AVDD-2.8750                |
| 231  | E7   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.8875                  | VDD2→VDD1             | 1.30                              | 2.50                              | 3.1 / 3.3                                      | 4                                   | 0                                      | 1200                          | 0                                   | 35                                  | 0.45 × AVDD-2.8875                |
| 232  | E8   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.9000                  | VDD2→VDD1             | 1.30                              | 2.55                              | 3.1 / 3.3                                      | 5                                   | 0                                      | 1200                          | 0                                   | 40                                  | 0.45 × AVDD-2.9000                |
| 233  | E9   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.9125                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 5                                   | 1                                      | 1200                          | 0                                   | 0                                   | 0.45 × AVDD-2.9125                |
| 234  | EA   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.9250                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 5                                   | 2                                      | 1200                          | 0                                   | 0                                   | 0.45 × AVDD-2.9250                |
| 235  | EB   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.9375                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 5                                   | 3                                      | 1200                          | 0                                   | 0                                   | 0.45 × AVDD-2.9375                |
| 236  | EC   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.9500                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 5                                   | 4                                      | 1200                          | 0                                   | 0                                   | 0.45 × AVDD-2.9500                |
| 237  | ED   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.9625                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 5                                   | 5                                      | 1200                          | 0                                   | 0                                   | 0.45 × AVDD-2.9625                |
| 238  | EE   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.9750                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 5                                   | 0                                      | 1200                          | 0                                   | 0                                   | 0.45 × AVDD-2.9750                |
| 239  | EF   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-2.9875                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 5                                   | 0                                      | 1200                          | 0                                   | 0                                   | 0.45 × AVDD-2.9875                |
| 240  | F0   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-3.0000                  | VDD2→VDD1             | 1.30                              | 1.70                              | 3.1 / 3.3                                      | 0                                   | 0                                      | 1200                          | 0                                   | 0                                   | 0.45 × AVDD-3.0000                |
| 241  | F1   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-3.0125                  | VDD2→VDD1             | 1.30                              | 1.75                              | 3.1 / 3.3                                      | 0                                   | 1                                      | 1200                          | 0                                   | 5                                   | 0.45 × AVDD-3.0125                |
| 242  | F2   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-3.0250                  | VDD2→VDD1             | 1.30                              | 1.80                              | 3.1 / 3.3                                      | 0                                   | 2                                      | 1200                          | 0                                   | 10                                  | 0.45 × AVDD-3.0250                |
| 243  | F3   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-3.0375                  | VDD2→VDD1             | 1.30                              | 1.85                              | 3.1 / 3.3                                      | 0                                   | 3                                      | 1200                          | 0                                   | 15                                  | 0.45 × AVDD-3.0375                |
| 244  | F4   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-3.0500                  | VDD2→VDD1             | 1.30                              | 1.90                              | 3.1 / 3.3                                      | 0                                   | 4                                      | 1200                          | 0                                   | 20                                  | 0.45 × AVDD-3.0500                |
| 245  | F5   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-3.0625                  | VDD2→VDD1             | 1.30                              | 2.40                              | 3.1 / 3.3                                      | 0                                   | 5                                      | 1200                          | 0                                   | 25                                  | 0.45 × AVDD-3.0625                |
| 246  | F6   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-3.0750                  | VDD2→VDD1             | 1.30                              | 2.45                              | 3.1 / 3.3                                      | 0                                   | 0                                      | 1200                          | 0                                   | 30                                  | 0.45 × AVDD-3.0750                |
| 247  | F7   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-3.0875                  | VDD2→VDD1             | 1.30                              | 2.50                              | 3.1 / 3.3                                      | 0                                   | 0                                      | 1200                          | 0                                   | 35                                  | 0.45 × AVDD-3.0875                |
| 248  | F8   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-3.1000                  | VDD2→VDD1             | 1.30                              | 2.55                              | 3.1 / 3.3                                      | 0                                   | 0                                      | 1200                          | 0                                   | 40                                  | 0.45 × AVDD-3.1000                |
| 249  | F9   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-3.1125                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 0                                   | 1                                      | 1200                          | 0                                   | 0                                   | 0.45 × AVDD-3.1125                |
| 250  | FA   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-3.1250                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 0                                   | 2                                      | 1200                          | 0                                   | 0                                   | 0.45 × AVDD-3.1250                |
| 251  | FB   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-3.1375                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 0                                   | 3                                      | 1200                          | 0                                   | 0                                   | 0.45 × AVDD-3.1375                |
| 252  | FC   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-3.1500                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 0                                   | 4                                      | 1200                          | 0                                   | 0                                   | 0.45 × AVDD-3.1500                |
| 253  | FD   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-3.1625                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 0                                   | 5                                      | 1200                          | 0                                   | 0                                   | 0.45 × AVDD-3.1625                |
| 254  | FE   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-3.1750                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 0                                   | 0                                      | 1200                          | 0                                   | 0                                   | 0.45 × AVDD-3.1750                |
| 255  | FF   | 8.0                               | 13.0                             | -9.5                             | 0.6 × AVDD-3.1875                  | VDD2→VDD1             | 1.30                              | 2.60                              | 3.1 / 3.3                                      | 0                                   | 0                                      | 1200                          | 0                                   | 0                                   | 0.45 × AVDD-3.1875                |

●Protection functions

• Over-Voltage Protection

|                 |                                                                                                                                                                         |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                 | AVDD                                                                                                                                                                    |
| Threshold (Typ) | 16V                                                                                                                                                                     |
| Operation       | When OVP is detected, switching turns OFF to control the rising output voltage.<br>When the output voltage decreases to a lower value, the switching will turn back ON. |

• Short Circuit Protection

|                 |                                                                                                                                                                                   |          |          |         |         |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|----------|---------|---------|
|                 | VDD1                                                                                                                                                                              | VDD2     | AVDD     | VGH     | VGL     |
| Threshold (Typ) | VDD1×0.8                                                                                                                                                                          | VDD2×0.8 | AVDD×0.8 | VGH×0.8 | VGL×0.8 |
| Operation       | When a channel detects SCP, a timer is activated.<br>10msec after that, all channels will be latched to shutdown state.<br>To return to normal operation, reset the power supply. |          |          |         |         |

• Over-Current Protect

|                 |                                                                                                                                                                          |      |      |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|
|                 | VDD1                                                                                                                                                                     | VDD2 | AVDD |
| Threshold (Min) | 1.0A                                                                                                                                                                     | 1.0A | 1.5A |
| Operation       | When OCP is detected, switching turns OFF to limit the FET from generating current.<br>When the FET current decreases to a lower value, the switching will turn back ON. |      |      |

• Thermal Shutdown

|                 |                                                                             |      |      |       |      |     |     |
|-----------------|-----------------------------------------------------------------------------|------|------|-------|------|-----|-----|
|                 | VDD1                                                                        | VDD2 | AVDD | HAVDD | VCOM | VGH | VGL |
| Threshold (Typ) | 175°C                                                                       |      |      |       |      |     |     |
| Operation       | When device temperature goes above 175°C (Typ), all channels are shut down. |      |      |       |      |     |     |

• VCC UVLO

|               |                                                                                                                                                                                                                           |      |      |       |      |     |     |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|-------|------|-----|-----|
|               | VDD1                                                                                                                                                                                                                      | VDD2 | AVDD | HAVDD | VCOM | VGH | VGL |
| Falling (Typ) | 2.4V                                                                                                                                                                                                                      |      |      |       |      |     |     |
| Rising (Typ)  | 2.1V                                                                                                                                                                                                                      |      |      |       |      |     |     |
| Operation     | Circuit malfunction is prevented by making sure the IC is turned off when VCC is below the UVLO threshold. There is a hysteresis between the rising and falling threshold to avoid triggering UVLO by power supply noise. |      |      |       |      |     |     |

• DC/DC converter UVLO

|                   |                                                                                                                                                 |      |      |       |      |     |     |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|------|------|-------|------|-----|-----|
|                   | VDD1                                                                                                                                            | VDD2 | AVDD | HAVDD | VCOM | VGH | VGL |
| Falling (Typ)     | 2.5 / 2.7 / 2.9 / 3.1V                                                                                                                          |      |      |       |      |     |     |
| Rising (Typ)      | 2.7 / 2.9 / 3.1 / 3.3 V                                                                                                                         |      |      |       |      |     |     |
| Watch start (Typ) | 2.8 / 3.0 / 3.2 / 3.4 V                                                                                                                         |      |      |       |      |     |     |
| Operation         | DC/DC converter output error is prevented by making sure all channels are turned off when a DC/DC converter output is below the UVLO threshold. |      |      |       |      |     |     |

**•FAULT Output**

The FAULT output indicates the status of the protection circuits of this IC.  
Because FAULT is an open-drain output, place a pull-up resistor externally.  
When the FAULT output will not be used, connect to GND.

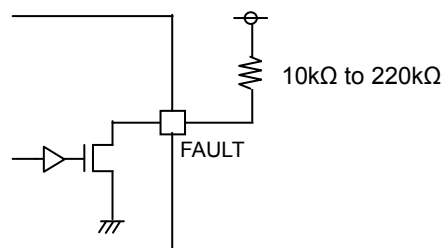


Fig. 55 FAULT Output

**FAULT=H**

During stable operation when none of the protection circuits are in effect.  
This is due to the external pull-up resistance.

**FAULT=L**

When any of the protection circuits (UVLO, OCP, OVP, TSD, and SCP) are triggered.  
This indicates a circuit error.

The recommended external pull-up resistance for the FAULT output is 10kΩ to 220kΩ. An external resistance of under 10kΩ can generate an offset voltage during FAULT=L caused by the voltage drop across the internal on resistance. On the other hand, an external resistance of more than 220kΩ can interfere with the output during FAULT=H because of leak current.

● I/O Equivalent Circuits

|                  |                  |                    |
|------------------|------------------|--------------------|
| 1.DRN, 28. DRP   | 2.AVDDP          | 3.HAVDD, 4.VCOM    |
|                  |                  |                    |
| 6.FAULT          | 7.VCC            | 8.SCL              |
|                  |                  |                    |
| 9.SDA            | 10.EN            | 11.VREG            |
|                  |                  |                    |
| 12.VDD2, 13.VDD1 | 15.SWB1, 17.SWB2 | 16.PVCC1, 22.PVCC2 |
|                  |                  |                    |



|         |         |                |
|---------|---------|----------------|
| 19.SW   | 20.AVDD | 21.AVDD_S      |
|         |         |                |
| 23.VLSO | 24.VGL  | 26.VGH, 27.CPP |
|         |         |                |

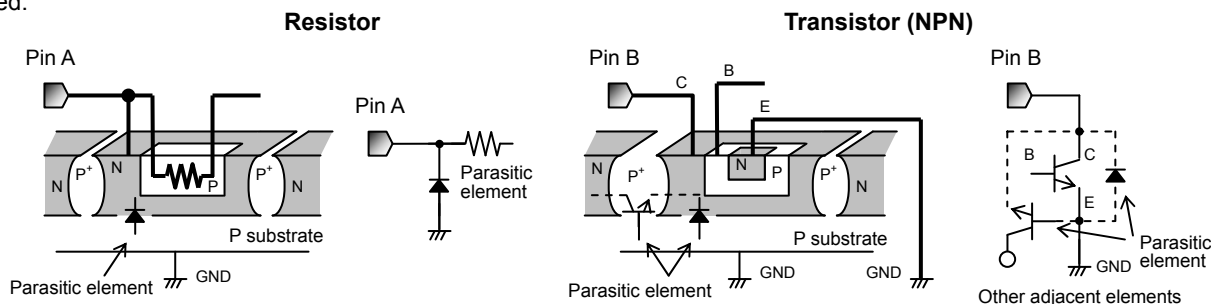
## ● Operational Notes

- 1) Absolute maximum ratings  
Operating the IC over the absolute maximum ratings may damage the IC. In addition, it is impossible to predict all destructive situations such as short-circuit modes, open circuit modes, etc. Therefore, it is important to consider circuit protection measures, like adding a fuse, in case the IC is operated in a special mode exceeding the absolute maximum ratings.
- 2) Ground potential  
The voltage of the ground pin must be the lowest voltage of all pins of the IC at all operating conditions. Ensure that no pins are at a voltage below the ground pin at any time, even during transient condition.
- 3) Thermal consideration  
Use a thermal design that allows for a sufficient margin by taking into account the permissible power dissipation ( $P_d$ ) in actual operating conditions.
- 4) Short between pins and mounting errors  
Be careful when mounting the IC on printed circuit boards. The IC may be damaged if it is mounted in a wrong orientation or if pins are shorted together. Short circuit may be caused by conductive particles caught between the pins.
- 5) Operation under strong electromagnetic field  
Operating the IC in the presence of a strong electromagnetic field may cause the IC to malfunction.
- 6) Testing on application boards  
When testing the IC on an application board, connecting a capacitor directly to a low-impedance output pin may subject the IC to stress. Always discharge capacitors completely after each process or step. The IC's power supply should always be turned off completely before connecting or removing it from the test setup during the inspection process. To prevent damage from static discharge, ground the IC during assembly and use similar precautions during transport and storage.
- 7) Regarding input pins of the IC  
This monolithic IC contains P+ isolation and P substrate layers between adjacent elements in order to keep them isolated. P-N junctions are formed at the intersection of the P layers with the N layers of other elements, creating a parasitic diode or transistor. For example (refer to figure below):

When  $GND > \text{Pin A}$  and  $GND > \text{Pin B}$ , the P-N junction operates as a parasitic diode.

When  $GND > \text{Pin B}$ , the P-N junction operates as a parasitic transistor.

Parasitic diodes inevitably occur in the structure of the IC. The operation of parasitic diodes can result in mutual interference among circuits, operational faults, or physical damage. Therefore, conditions that cause these diodes to operate, such as applying a voltage lower than the GND voltage to an input pin (and thus to the P substrate) should be avoided.



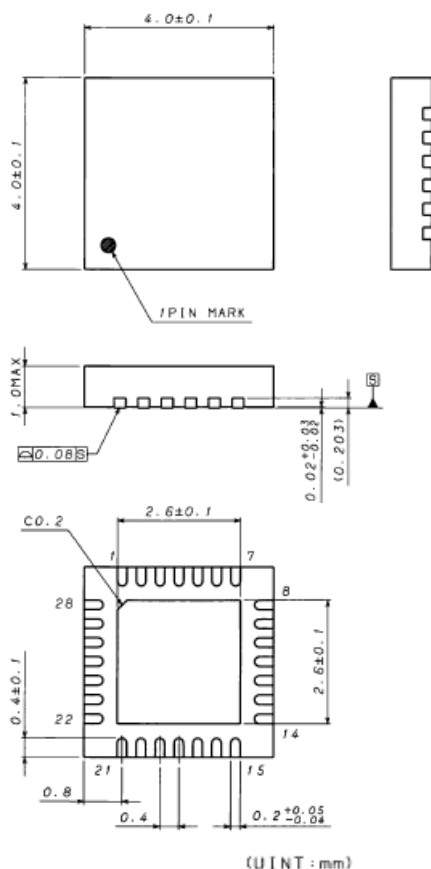
Example of a Simple Monolithic IC Structure

- 8) Over-current protection circuit (OCP)  
The IC incorporates an over-current protection circuit that operates in accordance with the rated output capacity. This circuit protects the IC from damage when the load becomes shorted. It is also designed to limit the output current (without latching) in the event of a large transient current flow, such as from a large capacitor or other component connected to the output pin. This protection circuit is effective in preventing damage to the IC in cases of sudden and unexpected current surges. The IC should not be used in applications where the over current protection circuit will be activated continuously.
- 9) Thermal shutdown circuit (TSD)  
The IC incorporates a built-in thermal shutdown circuit, which is designed to turn off the IC when the internal temperature of the IC reaches a specified value. It is not designed to protect the IC from damage or guarantee its operation. Do not continue to operate the IC after this function is activated. Do not use the IC in conditions where this function will always be activated.
- 10) DC/DC switching line wiring pattern  
DC/DC converter switching line (wiring from the switching pin to inductor, Nch MOS) must be as short and thick as possible to reduce line impedance. If the wiring is long, ringing caused by switching would increase and this may exceed the absolute maximum voltage ratings. If the parts are located far apart, consider inserting a snubber circuit.

## ●Ordering Information

|             |   |   |   |   |   |                              |   |   |   |                                                                    |  |     |
|-------------|---|---|---|---|---|------------------------------|---|---|---|--------------------------------------------------------------------|--|-----|
| B           | M | 8 | 1 | 0 | 2 | 8                            | A | M | W | V                                                                  |  | ZE2 |
| Part Number |   |   |   |   |   | Package<br>MWV: UQFN28V4040A |   |   |   | Packaging and forming specification<br>ZE2: Embossed tape and reel |  |     |

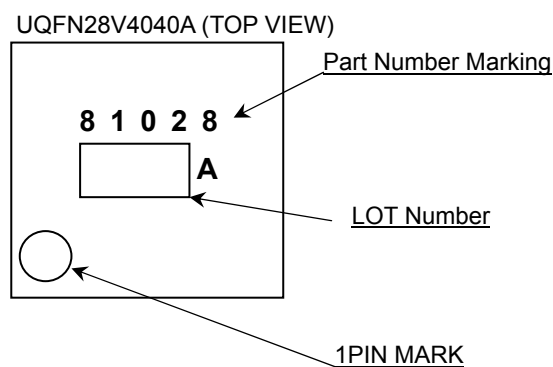
## ●Physical Dimension Tape and Reel Information



|                   |                                                                                                                                                                        |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Tape              | Embossed carrier tape                                                                                                                                                  |
| Quantity          | 2000pcs                                                                                                                                                                |
| Direction of feed | <p><b>ZE2</b></p> <p>( The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand )</p> |

The diagram illustrates the embossed carrier tape. It shows a series of six rectangular components, each with a small circle (pin) at the top center. An arrow labeled "Direction of feed" points to the right, indicating the direction of movement. Another arrow labeled "Reel" points to the left, indicating the direction of the tape's rotation. A label "1pin" points to the top center of the third component from the left, indicating the location of the first pin.

●Marking Diagram (TOP VIEW)



## ●MODIFICATION RECORD

|         |           |                                                                                                |
|---------|-----------|------------------------------------------------------------------------------------------------|
| Rev.001 | -         | Original                                                                                       |
| Rev.002 | P.1       | Change input voltage range, Add Input tolerant                                                 |
|         | P.5       | Change Recommended Operating Ratings<br>(Power Supply Voltage, SWB1,SWB2 Current, SW Current ) |
| Rev.003 | P.1, P.43 | Change package name                                                                            |
|         | P.26      | Clerical error correction (D1)                                                                 |

# Notice

## Precaution on using ROHM Products

- Our Products are designed and manufactured for application in ordinary electronic equipments (such as AV equipment, OA equipment, telecommunication equipment, home electronic appliances, amusement equipment, etc.). If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment <sup>(Note 1)</sup>, transport equipment, traffic equipment, aircraft/spacecraft, nuclear power controllers, fuel controllers, car equipment including car accessories, safety devices, etc.) and whose malfunction or failure may cause loss of human life, bodily injury or serious damage to property ("Specific Applications"), please consult with the ROHM sales representative in advance. Unless otherwise agreed in writing by ROHM in advance, ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of any ROHM's Products for Specific Applications.

(Note1) Medical Equipment Classification of the Specific Applications

| JAPAN     | USA       | EU         | CHINA     |
|-----------|-----------|------------|-----------|
| CLASS III | CLASS III | CLASS II b | CLASS III |
| CLASS IV  |           | CLASS III  |           |

- ROHM designs and manufactures its Products subject to strict quality control system. However, semiconductor products can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against the physical injury, damage to any property, which a failure or malfunction of our Products may cause. The following are examples of safety measures:
  - Installation of protection circuits or other protective devices to improve system safety
  - Installation of redundant circuits to reduce the impact of single or multiple circuit failure
- Our Products are designed and manufactured for use under standard conditions and not under any special or extraordinary environments or conditions, as exemplified below. Accordingly, ROHM shall not be in any way responsible or liable for any damages, expenses or losses arising from the use of any ROHM's Products under any special or extraordinary environments or conditions. If you intend to use our Products under any special or extraordinary environments or conditions (as exemplified below), your independent verification and confirmation of product performance, reliability, etc. prior to use, must be necessary:
  - Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
  - Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
  - Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, and NO<sub>2</sub>
  - Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
  - Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
  - Sealing or coating our Products with resin or other coating materials
  - Use of our Products without cleaning residue of flux (even if you use no-clean type fluxes, cleaning residue of flux is recommended); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
  - Use of the Products in places subject to dew condensation
- The Products are not subject to radiation-proof design.
- Please verify and confirm characteristics of the final or mounted products in using the Products.
- In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse. is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.
- De-rate Power Dissipation (Pd) depending on Ambient temperature (Ta). When used in sealed area, confirm the actual ambient temperature.
- Confirm that operation temperature is within the specified range described in the product specification.
- ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

## Precaution for Mounting / Circuit board design

- When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.
- In principle, the reflow soldering method must be used on a surface-mount products, the flow soldering method must be used on a through hole mount products. If the flow soldering method is preferred on a surface-mount products, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

## Precautions Regarding Application Examples and External Circuits

1. If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.
2. You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

## Precaution for Electrostatic

This Product is electrostatic sensitive product, which may be damaged due to electrostatic discharge. Please take proper caution in your manufacturing process and storage so that voltage exceeding the Products maximum rating will not be applied to Products. Please take special care under dry condition (e.g. Grounding of human body / equipment / solder iron, isolation from charged objects, setting of ionizer, friction prevention and temperature / humidity control).

## Precaution for Storage / Transportation

1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
  - [a] the Products are exposed to sea winds or corrosive gases, including Cl<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, and NO<sub>2</sub>
  - [b] the temperature or humidity exceeds those recommended by ROHM
  - [c] the Products are exposed to direct sunshine or condensation
  - [d] the Products are exposed to high Electrostatic
2. Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.
3. Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.
4. Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

## Precaution for Product Label

QR code printed on ROHM Products label is for ROHM's internal use only.

## Precaution for Disposition

When disposing Products please dispose them properly using an authorized industry waste company.

## Precaution for Foreign Exchange and Foreign Trade act

Since concerned goods might be fallen under listed items of export control prescribed by Foreign exchange and Foreign trade act, please consult with ROHM in case of export.

## Precaution Regarding Intellectual Property Rights

1. All information and data including but not limited to application example contained in this document is for reference only. ROHM does not warrant that foregoing information or data will not infringe any intellectual property rights or any other rights of any third party regarding such information or data.
2. ROHM shall not have any obligations where the claims, actions or demands arising from the combination of the Products with other articles such as components, circuits, systems or external equipment (including software).
3. No license, expressly or implied, is granted hereby under any intellectual property rights or other rights of ROHM or any third parties with respect to the Products or the information contained in this document. Provided, however, that ROHM will not assert its intellectual property rights or other rights against you or your customers to the extent necessary to manufacture or sell products containing the Products, subject to the terms and conditions herein.

## Other Precaution

1. This document may not be reprinted or reproduced, in whole or in part, without prior written consent of ROHM.
2. The Products may not be disassembled, converted, modified, reproduced or otherwise changed without prior written consent of ROHM.
3. In no event shall you use in any way whatsoever the Products and the related technical information contained in the Products or this document for any military purposes, including but not limited to, the development of mass-destruction weapons.
4. The proper names of companies or products described in this document are trademarks or registered trademarks of ROHM, its affiliated companies or third parties.

**General Precaution**

1. Before you use our Products, you are requested to carefully read this document and fully understand its contents. ROHM shall not be in any way responsible or liable for failure, malfunction or accident arising from the use of any ROHM's Products against warning, caution or note contained in this document.
2. All information contained in this document is current as of the issuing date and subject to change without any prior notice. Before purchasing or using ROHM's Products, please confirm the latest information with a ROHM sales representative.
3. The information contained in this document is provided on an "as is" basis and ROHM does not warrant that all information contained in this document is accurate and/or error-free. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties resulting from inaccuracy or errors of or concerning such information.