

Power Supply IC Series for TFT-LCD Panels

# Automotive Panel Power Management IC

## BM81810MUV-M

### General Description

BM81810MUV-M is a power management IC for TFT-LCD panels which are used in car navigation, in-vehicle center panel, and instrument cluster. This IC incorporates VCOM amplifier, Gate Pulse Modulation (GPM) 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.

### Key Specifications

|                                |                         |
|--------------------------------|-------------------------|
| ■ Input voltage range:         | 2.6V to 5.5V            |
| ■ AVDD Output voltage range:   | 5.0V to 17.0V           |
| ■ VGH Output voltage range:    | 8.0V to 35.0V           |
| ■ VGL Output voltage range:    | -4.0V to -14.0V         |
| ■ VDD Output voltage range:    | 0.9V to 3.4V            |
| ■ VCOM Output current:         | 200 mA (Typ)            |
| ■ Switching Frequency:         | 525KHz, 1.05MHz, 2.1MHz |
| ■ Operating temperature range: | -40°C to +105°C         |
| ■ Standby current:             | 2.0 μA (Typ)            |

### Special Characteristics

|                                 |      |
|---------------------------------|------|
| ■ AVDD output voltage accuracy: | ±2%  |
| ■ Oscillator Frequency:         | ±10% |

### Applications

TFT-LCD Panels which are used in car navigation, in-vehicle center panel, and instrument cluster.

### Features

- AEC-Q100 Qualified<sup>(Note 1)</sup>
- Alternative Synchronous Buck DC/DC converter or LDO for VDD output
- Synchronous Boost DC/DC converter for AVDD output with integrated load switch.
- VCOM amplifier with 7bit calibrator
- Positive charge pump (Integrated diode, x2/x3) for VGH output
- Negative charge pump for VGL output
- VGH and VCOM temperature compensation
- Gate Pulse Modulation(GPM)
- I<sup>2</sup>C Interface Output Voltage Setting Control Function (Integrated EEPROM)
- Switching frequency switching function (525kHz, 1.05MHz, 2.1MHz)
- Protection circuits
  - Under-Voltage Lockout
  - Thermal Shut Down
  - Over-Current Protection
  - Over-Voltage Protection
  - Under Voltage Protection (Timer Latch type)
- Input tolerant (SCL, SDA, EN, GSIN) (Note1: Grade 2)

### Package

VQFN32SV5050

### W(Typ) x D(Typ) x H(Max)

5.0mm x 5.0mm x 1.0mm

### Typical Application Circuit (TOP VIEW)

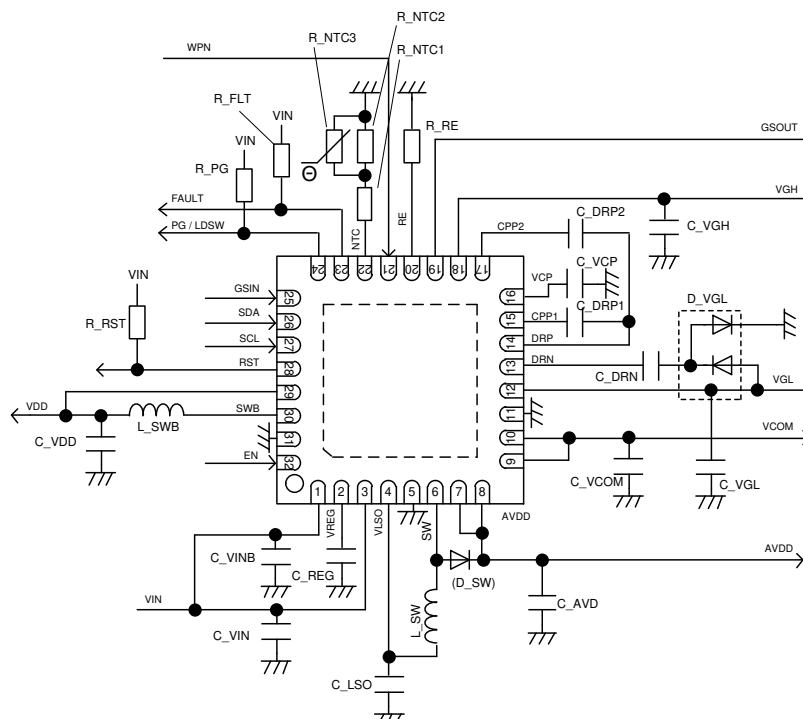


Figure 1. Application Circuit

○Product structure : Silicon integrated circuit ○This product has no designed protection against radioactive rays.

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Pin Configuration (TOP VIEW)

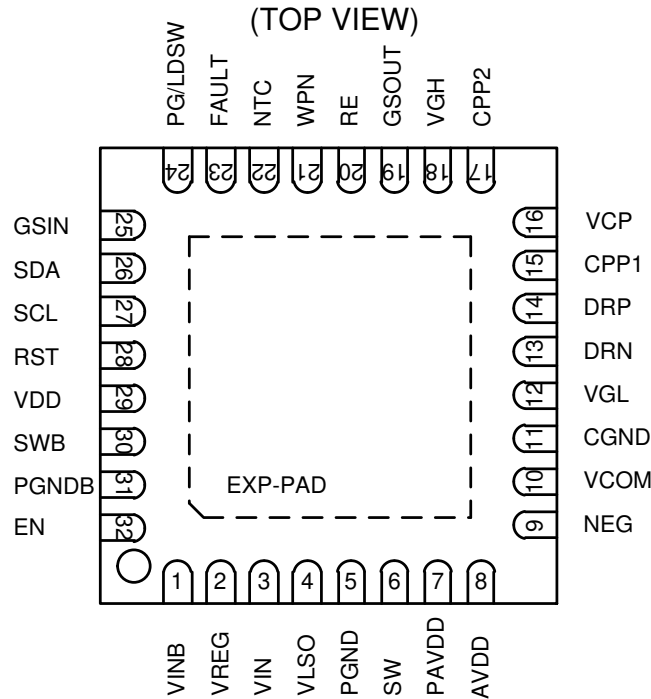


Figure 2. Pin Configuration

Pin Descriptions

| Pin No. | Pin Name | Function  | Pin No. | Pin Name | Function   |
|---------|----------|---|---------|----------|--|
| 1       | VINB     | Buck DC/DC power supply input                           | 17      | CPP2     | Built-in Positive charge pump switching Di output 3                  |
| 2       | VREG     | Inner power supply output                               | 18      | VGH      | Positive charge pump feedback & Power Input of Gate Pulse Modulation |
| 3       | VIN      | Boost DC/DC load switch input                           | 19      | GSOUT    | Output of Gate Pulse Modulation                                      |
| 4       | VLSD     | Boost DC/DC load switch output                          | 20      | RE       | Slope Setting Pin for Gate Pulse Modulation                          |
| 5       | PGND     | Boost DC/DC ground                                      | 21      | WPN      | Active Low of EEPROM Writing protection.                             |
| 6       | SW       | Boost DC/DC switching pin                               | 22      | NTC      | Slope setting pin for temperature compensation of the VON and VCOM   |
| 7       | PAVDD    | Boost DC/DC output & output feedback Power Input of DRN | 23      | FAULT    | FAULT signal output  |
| 8       | AVDD     | Power Input of VCOM , DRP                               | 24      | PG/LDSW  | Power Good signal output or Load SW of PAVDD.                        |
| 9       | NEG      | Negative Input of VCOM Amplifier                        | 25      | GSIN     | Input of Gate Pulse Modulation                                       |
| 10      | VCOM     | VCOM amplifier output                                   | 26      | SDA      | Serial clock data input (I2C)  |
| 11      | CGND     | Charge pump ground                                      | 27      | SCL      | Serial clock input (I2C)   |
| 12      | VGL      | Negative charge pump feedback                           | 28      | RST      | Reset output   |
| 13      | DRN      | Negative charge pump driver pin                         | 29      | VDD      | Buck DC/DC or LDO output feedback input                              |
| 14      | DRP      | Positive charge pump driver pin                         | 30      | SWB      | Buck DC/DC switching pin or LDO output pin                           |
| 15      | CPP1     | Built-in Positive charge pump switching Di output 1     | 31      | PGNDB    | Buck DC/DC ground  |
| 16      | VCP      | Built-in Positive charge pump switching Di output 2     | 32      | EN       | Enable input   |
|         |          |   | -       | EXP-PAD  | Connect to Ground.   |

## Absolute Maximum Ratings

| Parameter                    | Symbol             | Limits |     |           | Unit |
|------------------------------|--------------------|--------|-----|-----------|------|
|                              |                    | Min    | Typ | Max       |      |
| Power Supply Voltage         | VIN, VINB          | -0.3   | -   | +6.5      | V    |
| Output Pin                   | SWB                | -0.3   | -   | VINB+0.3  | V    |
|                              | VDD                | -0.3   | -   | +6.5      | V    |
|                              | AVDD, PAVDD, SW    | -0.3   | -   | +19       | V    |
|                              | VLSO               | -0.3   | -   | +6.5      | V    |
|                              | VCOM               | -0.3   | -   | AVDD+0.3  | V    |
|                              | DRP                | -0.3   | -   | AVDD+0.3  | V    |
|                              | DRN                | -0.3   | -   | PAVDD+0.3 | V    |
|                              | CPP1, CPP2, VCP    | -0.3   | -   | +36       | V    |
|                              | VGH, GSOUT, RE     | -0.3   | -   | +36       | V    |
|                              | VGL                | -15    | -   | +0.3      | V    |
|                              | VREG               | -0.3   | -   | VIN+0.3   | V    |
|                              | FAULT              | -0.3   | -   | +6.5      | V    |
|                              | PG/LDSW            | -0.3   | -   | +19       | V    |
|                              | RST, NTC           | -0.3   | -   | VIN+0.3   | V    |
| Input Pin                    | NEG                | -0.3   | -   | AVDD+0.3  | V    |
| Functional Pin Voltage       | SCL, SDA, EN, GSIN | -0.3   | -   | +6.5      | V    |
|                              | WPN                | -0.3   | -   | VIN+0.3   | V    |
| Maximum Junction temperature | Tjmax (Note 1)     | -      | -   | +150      | °C   |
| Storage Temperature Range    | Tstg               | -55    | -   | +150      | °C   |

(Note 1) Junction temperature at storage time.

Caution : Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.

**Thermal Resistance** (Note 1)

| Parameter  | Symbol        | Thermal Resistance (Typ) |                          | Unit |
|--|---------------|--------------------------|--------------------------|------|
|  |               | 1s <sup>(Note 3)</sup>   | 2s2p <sup>(Note 4)</sup> |      |
| VQFN32SV5050   |               |                          |                          |      |
| Junction to Ambient  | $\theta_{JA}$ | 138.9                    | 39.1                     | °C/W |
| Junction to Top Characterization Parameter <sup>(Note 2)</sup> | $\Psi_{JT}$   | 11                       | 5                        | °C/W |

(Note 1)Based on JESD51-2A(Still-Air).

(Note 2)The thermal characterization parameter to report the difference between junction temperature and the temperature at the top center of the outside surface of the component package.

(Note 3)Using a PCB board based on JESD51-3.

| Layer Number of Measurement Board | Material | Board Size                |
|-----------------------------------|----------|---------------------------|
| Single                            | FR-4     | 114.3mm x 76.2mm x 1.57mm |

| Top                   |           |
|-----------------------|-----------|
| Copper Pattern        | Thickness |
| Footprints and Traces | 70μm      |

(Note 4)Using a PCB board based on JESD51-5, 7.

| Layer Number of Measurement Board | Material | Board Size               | Thermal Via <sup>(Note 5)</sup> |          |
|-----------------------------------|----------|--------------------------|---------------------------------|----------|
|                                   |          |                          | Pitch                           | Diameter |
| 4 Layers                          | FR-4     | 114.3mm x 76.2mm x 1.6mm | 1.20mm                          | Φ0.30mm  |

| Top                   |           | 2 Internal Layers |           | Bottom          |           |
|-----------------------|-----------|-------------------|-----------|-----------------|-----------|
| Copper Pattern        | Thickness | Copper Pattern    | Thickness | Copper Pattern  | Thickness |
| Footprints and Traces | 70μm      | 74.2mm x 74.2mm   | 35μm      | 74.2mm x 74.2mm | 70μm      |

(Note 5) This thermal via connects with the copper pattern of all layers.

**Recommended Operating Ratings (Ta=-40 °C to +105 °C)**

| Parameter                      | Symbol        | Min  | Typ | Max  | Unit |
|--------------------------------|---------------|------|-----|------|------|
| Power Supply Voltage           | VIN, VINB     | 2.6  | -   | 5.5  | V    |
| SWB Current                    | ISWB          | -    | -   | 1.0  | A    |
| SW Current                     | ISW           | -    | -   | 2.0  | A    |
| Functional Pin Voltage         | EN, GSIN, WPN | -0.1 | -   | +5.5 | V    |
| 2 Line Serial Pin Voltage      | SDA, SCL      | -0.1 | -   | +5.5 | V    |
| 2 Line Serial Frequency        | FCLK          | -    | -   | 400  | kHz  |
| Operating Ambient Temperature  | TA            | -40  | -   | +105 | °C   |
| Operating Junction Temperature | TJ            | -40  | -   | +125 | °C   |

Electrical Characteristics (Unless otherwise specified, Ta=25°C, VIN, VINB=3.3V)

1. VDD regulator block (Alternative Buck converter or LDO)

| Parameter                        | Symbol    | Limits  |         |         | Unit | Condition  |
|----------------------------------|-----------|---------|---------|---------|------|--|
|                                  |           | Min     | Typ     | Max     |      |  |
| Output Voltage Range             | VDD       | 0.9     | -       | 3.4     | V    | 50 mV step   |
| Output Voltage Accuracy 1        | VDD_R1    | 2.462   | 2.5     | 2.538   | V    | VDD=2.5 V setting  |
| Output Voltage Accuracy 2        | VDD_R2    | -2.0    | -       | +2.0    | %    | VDD=2.5 V to 3.4 V setting<br>(Ta=-40 to +105 °C)                  |
| Output Voltage Accuracy 3        | VDD_R3    | -3.0    | -       | +3.0    | %    | VDD=0.9 V to 2.45 V setting<br>(Ta=-40 to +105 °C)                 |
| Soft Start time                  | VDD_SS    | 0.85    | 1       | 1.15    | msec | VDD=1.2 V setting  |
| Under-Voltage Protection voltage | VDD_UVP   | VDD×0.7 | VDD×0.8 | VDD×0.9 | V    |  |
| SWB H Side ON Resistance         | RONH_SWB  | -       | 300     | 480     | mΩ   | DCDC mode  |
| SWB L Side ON Resistance         | RONL_SWB  | -       | 300     | 480     | mΩ   | DCDC mode  |
| SWB H Side ON Resistance         | RON_SWB   | -       | 1.0     | 2.0     | Ω    | LDO mode   |
| SWB H Side Leak Current          | IL_SWBH   | -       | 0       | 20      | μA   | (Ta=-40 to +105 °C)  |
| SWB L Side Leak Current          | IL_SWBL   | -       | 0       | 20      | μA   | (Ta=-40 to +105 °C)  |
| Current Limit                    | ILMT_SWB1 | 1.0     | 1.7     | 2.7     | A    | Buck DCDC mode   |
| Current Limit                    | ILMT_SWB2 | 0.3     | 0.5     | 0.7     | A    | LDO mode   |
| Maximum Duty                     | DMAX_SWB  | 87      | 95      | -       | %    | Freq=1.05 MHz<br>(Freq=0.525 MHz:98%typ)<br>(Freq=2.10 MHz:87%typ) |
| Discharge Resistance             | DISR_VDD  | -       | 25      | 50      | Ω    |  |

2. Boost DC/DC converter block (AVDD)

| Parameter                        | Symbol    | Limits    |          |          | Unit | Condition  |
|----------------------------------|-----------|-----------|----------|----------|------|--|
|                                  |           | Min       | Typ      | Max      |      |  |
| Output Voltage Range             | AVDD      | 5.0       | -        | 17.0     | V    | 0.1 V step   |
| Output Voltage Accuracy1         | AVDD_R1   | 10.342    | 10.5     | 10.66    | V    | AVDD=10.5 V setting  |
| Output Voltage Accuracy2         | AVDD_R2   | 10.29     | 10.5     | 10.71    | V    | AVDD=10.5 V setting<br>(Ta=-40 to +105 °C)                         |
| Load Switch Soft Start time      | LS_SS     | 1.7       | 2        | 2.3      | msec |  |
| Soft Start Time                  | AVDD_SS   | 4.25      | 5        | 5.75     | msec | AVDD=10.5 V setting<br>5 ms setting                                |
| Under-Voltage Protection voltage | AVDD_UVP  | AVDD×0.7  | AVDD×0.8 | AVDD×0.9 | V    |  |
| Over-Voltage Protection voltage  | AVDD_OVP  | AVDD×1.03 | AVDD×1.1 | AVDD×1.2 | V    |  |
| SW H Side On Resistance          | RON_SW    | -         | 250      | 480      | mΩ   |  |
| SW L Side On Resistance          | RON_SW    | -         | 200      | 350      | mΩ   |  |
| SW H Side Leak Current           | IL_SWH    | -         | 0        | 20       | μA   | (Ta=-40 to +105 °C)  |
| SW L Side Leak Current           | IL_SWL    | -         | 0        | 20       | μA   | (Ta=-40 to +105 °C)  |
| Current Limit                    | ILMT_SW   | 2.0       | 4.0      | 6.0      | A    | AVDD OCP=2 A setting   |
| Current Limit                    | ILMT_SW   | 1.0       | 2.0      | 2.5      | A    | AVDD OCP=1 A setting   |
| Load Switch ON Resistance        | RON_LS    | -         | 200      | 350      | mΩ   |  |
| Maximum Duty                     | DMAX_SW   | 83        | 90       | -        | %    | Freq=1.05 MHz<br>(Freq=0.525 MHz:95%typ)<br>(Freq=2.10 MHz:80%typ) |
| Discharge Resistance             | DISR_AVDD | -         | 25       | 50       | Ω    |  |

Electrical Characteristics (Unless otherwise specified, Ta=25°C, VIN, VINB=3.3V) – continued

3. VCOM amplifier block (VCOM)

| Parameter                              | Symbol    | Limits          |           |                 | Unit   | Condition           |
|--|-----------|-----------------|-----------|-----------------|--------|---------------------|
|  |           | Min             | Typ       | Max             |        |                     |
| Output Voltage Range1                  | VCOM_HOT  | 0.5x AVDD - 4.0 | 0.5x AVDD | 0.5x AVDD + 4.0 | V      | 40 mV step          |
| Output Voltage Range2                  | VCOM_COLD | VCOM HOT - 0.63 | -         | VCOM HOT        | V      | 10 mV step          |
| Output Voltage Range3                  | VCOM_CAL  | VCOM HOT - 0.63 | VCOM HOT  | VCOM HOT +0.63V | V      | 10 mV step          |
| Output Voltage Range4                  | VCOM_RNG  | 0.2xAVDD        | -         | 0.7x AVDD       | V      |                     |
| Calibration Resolution                 | RES_CAL   | -               | 7         | -               | Bit    |                     |
| Integral Non-Linearity Error (INL)     | INL_CAL   | -1              | -         | +1              | LSB    |                     |
| Differential Non-Linearity Error (DNL) | DNLCAL    | -1              | -         | +1              | LSB    |                     |
| Output Current Ability (Source)        | ISOURCE   | -               | 200       | -               | mA     |                     |
| Output Current Ability (Sink)          | ISINK     | -               | 200       | -               | mA     |                     |
| Load Stability                         | VLOAD     | -               | 10        | 70              | mV     | Io=-15 mA to +15 mA |
| Slew Rate                              | SR        | 30              | 60        | 80              | V/μsec |                     |

4. Positive charge pump block (VGH)

| Parameter                        | Symbol   | Limits  |         |              | Unit | Condition                               |
|----------------------------------|----------|---------|---------|--------------|------|---|
|                                  |          | Min     | Typ     | Max          |      |   |
| Output Voltage Range 1           | VGH_HOT  | 8.0     | -       | 35           | V    | 0.2 V step                              |
| Output Voltage Range 2           | VGH_COLD | VGH HOT | -       | VGH HOT +15V | V    | 0.2 V step<br>*Max = 35 V               |
| Output Voltage Accuracy 1        | VGH_R1   | 17.46   | 18      | 18.54        | V    | VGH=18 V setting                        |
| Output Voltage Accuracy 2        | VGH_R2   | 17.1    | 18      | 18.9         | V    | VGH=18 V setting<br>(Ta=-40 to +105 °C) |
| Soft Start time                  | VGH_SS   | 4.25    | 5       | 5.75         | msec | VGH=18 V setting                        |
| Under-Voltage Protection voltage | VGH_UVP  | VGH×0.7 | VGH×0.8 | VGH×0.9      | V    |   |
| DRP H Side On Resistance         | RON_DRPH | -       | 10      | 20           | Ω    |   |
| DRP L Side On Resistance         | RON_DRPL | -       | 10      | 20           | Ω    |   |
| AVDD-CPP1 On Resistance          | RON_CPP1 | -       | 10      | 20           | Ω    |   |
| CPP1-VCP On Resistance           | RON_CPP2 | -       | 10      | 20           | Ω    |   |
| VCP-CPP2 On Resistance           | RON_CPP3 | -       | 10      | 20           | Ω    |   |
| CPP2-VGH On Resistance           | RON_CPP4 | -       | 10      | 20           | Ω    |   |
| Discharge Resistance             | DISR_VGH | -       | 150     | 300          | Ω    |   |

5. Negative charge pump block (VGL)

| Parameter                        | Symbol   | Limits  |         |         | Unit | Condition                                 |
|----------------------------------|----------|---------|---------|---------|------|---|
|                                  |          | Min     | Typ     | Max     |      |   |
| Output Voltage Range             | VGL      | -14.0   | -       | -4.0    | V    | 0.1 V step                                |
| Output Voltage Accuracy 1        | VGL_R1   | -6.18   | -6      | -5.82   | V    | VGL=-6.0 V setting                        |
| Output Voltage Accuracy 2        | VGL_R2   | -6.3    | -6      | -5.7    | V    | VGL=-6.0 V setting<br>(Ta=-40 to +105 °C) |
| Soft Start time                  | VGL_SS   | 4.25    | 5       | 5.75    | msec |   |
| Under-Voltage Protection voltage | VGL_UVP  | VGL×0.7 | VGL×0.8 | VGL×0.9 | V    |   |
| DRN H Side On Resistance         | RON_DRNH | -       | 10      | 20      | Ω    |   |
| DRN L Side On Resistance         | RON_DRNN | -       | 10      | 20      | Ω    |   |
| Discharge Resistance             | DISR_VGL | -       | 250     | 500     | Ω    |   |

## Electrical Characteristics (Unless otherwise specified, Ta=25°C, VIN, VINB=3.3V) – continued

## 6. Temperature compensation block (NTC)

| Parameter        | Symbol  | Limits |      |        | Unit | Condition |
|------------------|---------|--------|------|--------|------|-----------|
|                  |         | Min    | Typ  | Max    |      |           |
| NTC HOT Voltage  | VNTC_H  | 0.475  | 0.5  | 0.525  | V    |           |
| NTC COLD Voltage | VNTC_H  | 1.1875 | 1.25 | 1.3125 | V    |           |
| NTC Current      | INTC    | 36     | 40   | 44     | μA   |           |
| NTC Resolution   | RES_NTC | -      | 4    | -      | Bit  |           |

## 7. Gate Pulse Modulation block (GPM)

| Parameter                     | Symbol   | Limits |     |      | Unit | Condition                            |
|-------------------------------|----------|--------|-----|------|------|--------------------------------------|
|                               |          | Min    | Typ | Max  |      |                                      |
| GPM High Switch On Resistance | RON_GPMH | -      | 15  | 30   | Ω    |                                      |
| GPM Low Switch On Resistance  | RON_GPML | -      | 30  | -    | Ω    |                                      |
| GPM Propagation Delay1        | T_GPM1   | -      | 0.1 | 0.3  | μsec | No Capacitive Load<br>0.1 μS setting |
| GPM Propagation Delay2        | T_GPM2   | -      | 0.5 | 1.0  | μsec | No Capacitive Load<br>0.5 μS setting |
| GPM Propagation Delay3        | T_GPM3   | -      | 1.0 | 1.75 | μsec | No Capacitive Load<br>1.0 μS setting |
| GPM Propagation Delay4        | T_GPM4   | -      | 1.5 | 2.5  | μsec | No Capacitive Load<br>1.5 μS setting |
| GSIN Pull Down Resistance     | RGSIN    | 70     | 100 | 130  | kΩ   |                                      |
| GSIN Input High Voltage       | VGSINH   | 1.5    | -   | -    | V    |                                      |
| GSIN Input Low Voltage        | VGSINL   | -      | -   | 0.6  | V    |                                      |



## Electrical Characteristics (Unless otherwise specified, Ta=25°C, VIN, VINB=3.3V) – continued

## 8. 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=5 mA                    |
| Oscillator Block                      |            |        |      |      |            |                               |
| Oscillating Frequency 1               | FOSC1      | 475    | 525  | 575  | KHz        |                               |
| Oscillating Frequency 2               | FOSC2      | 950    | 1050 | 1150 | KHz        |                               |
| Oscillating Frequency 3               | FOSC3      | 1900   | 2100 | 2300 | KHz        |                               |
| Under Voltage Lock Out (UVLO) Circuit |            |        |      |      |            |                               |
| UVLO release voltage                  | VUVLO1     | 2.5    | 2.55 | 2.6  | V          |                               |
| UVLO detection voltage                | VUVLO2     | 2.0    | 2.1  | 2.2  | V          |                               |
| Hysteresis                            | VHYS_UVL   | -      | 0.45 | -    | V          |                               |
| Reset Circuit Block                   |            |        |      |      |            |                               |
| Reset Voltage Range                   | VRST       | 0.6    | *    | 3.3  | V          | 0.1 V step                    |
| Reset Voltage Accuracy                | VRST_R1    | 1.9    | 2.0  | 2.1  | V          | VRST=2.0 V setting            |
| Hysteresis                            | VHYS_RST   | -      | 0.1  | -    | V          |                               |
| Reset Delay time Range                | T_Delay2   | 0      | -    | 40   | msec       |                               |
| FAULT/ PG / RST Signal Output Block   |            |        |      |      |            |                               |
| Output Off Leak Current               | IL         | -      | 0    | 10   | $\mu$ A    |                               |
| Output On Resistance                  | RON_O      | -      | 1    | 2    | k $\Omega$ |                               |
| Control Signal Block1 SDA, SCL, WPN   |            |        |      |      |            |                               |
| Minimum Output Voltage                | VSDA       | -      | -    | 0.4  | V          | ISDA=3 mA                     |
| H Level Input Voltage                 | VIH        | 1.5    | -    | -    | V          |                               |
| L Level Input Voltage                 | VIL        | -      | -    | 0.6  | V          |                               |
| WPN Pull Down Resistance              | RWPN       | 70     | 100  | 130  | k $\Omega$ |                               |
| Control Signal Block2 EN              |            |        |      |      |            |                               |
| Pull-Down Resistance Value            | REN_L      | 280    | 400  | 520  | k $\Omega$ | EN=Low                        |
|                                       | REN_H      | 420    | 600  | 780  | k $\Omega$ | EN=High                       |
| H Level Input Voltage                 | VENH       | 1.5    | -    | -    | V          |                               |
| L Level Input Voltage                 | VENL       | -      | -    | 0.6  | V          |                               |
| Overall                               |            |        |      |      |            |                               |
| Standby Current1                      | ISTB1      | -      | 2.0  | 5.0  | $\mu$ A    | EN=GND                        |
| Standby Current2                      | ISTB2      | -      | -    | 20   | $\mu$ A    | EN=GND<br>(Ta=-40 to +105 °C) |
| Consumption Current                   | ICC1       | -      | 2.0  | 5.0  | mA         | EN=VIN, No switching          |

## 9. EEPROM

| Parameter         | Symbol | Limits |     |     | Unit  | Condition |
|-------------------|--------|--------|-----|-----|-------|-----------|
|                   |        | Min    | Typ | Max |       |           |
| Rewritable cycle  | Cyc    | 100    | -   | -   | Times | TJ<125 °C |
| Programmable time | Twr    | -      | -   | 50  | msec  |           |
| Data hold years   | DHY    | 20     | -   | -   | Years | TJ<125 °C |

Typical Performance Curves

(Unless otherwise specified VIN=3.3V, VDD=2.5V, AVDD=10.5V, VGH=18V, VGL=-6.0V, VCOM=5.25V and Ta=25°C)

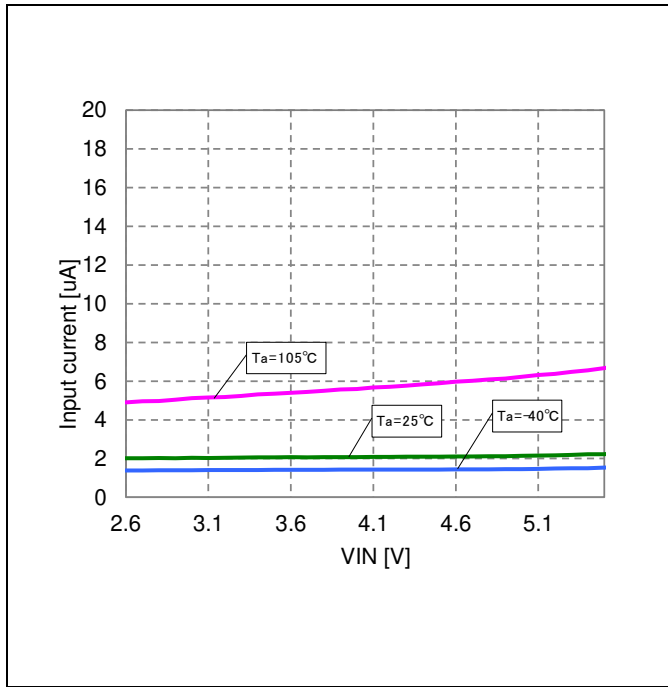


Figure 3. Standby Current(EN=L)

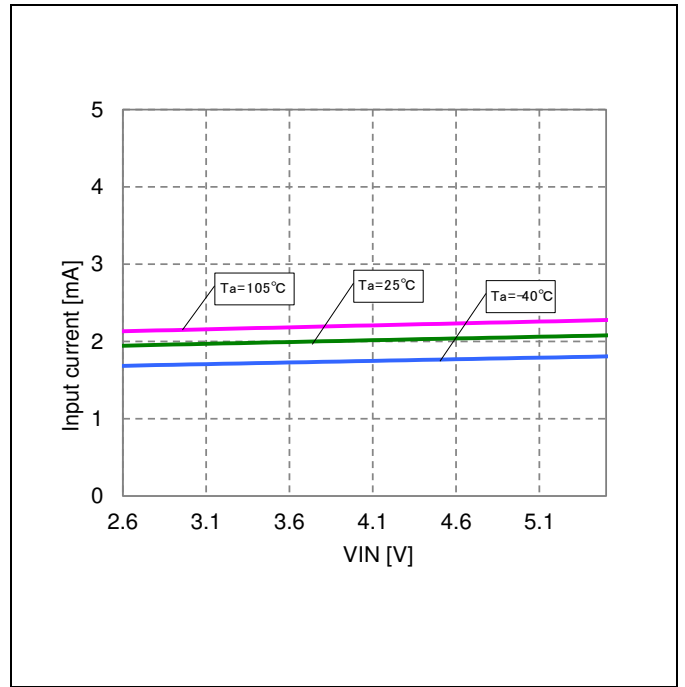


Figure 4. Circuit Current(EN=H, no switching)

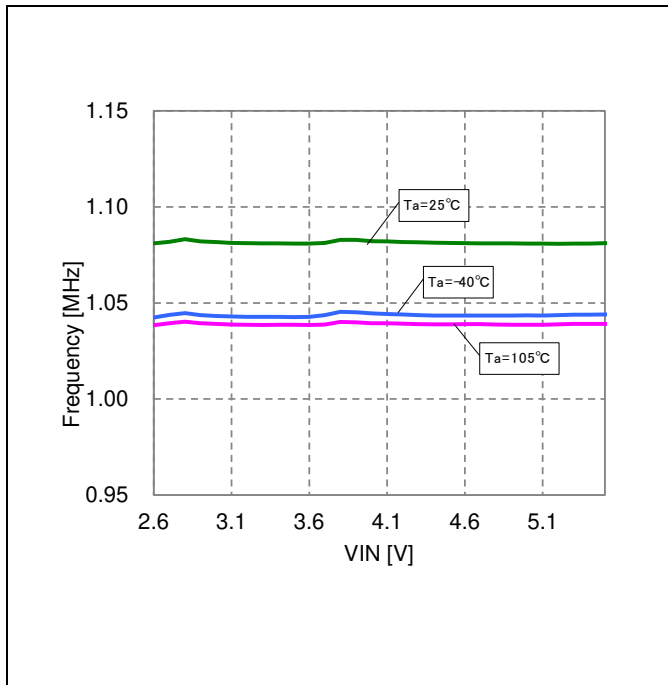


Figure 5. Switching Frequency (Dependent on input voltage)

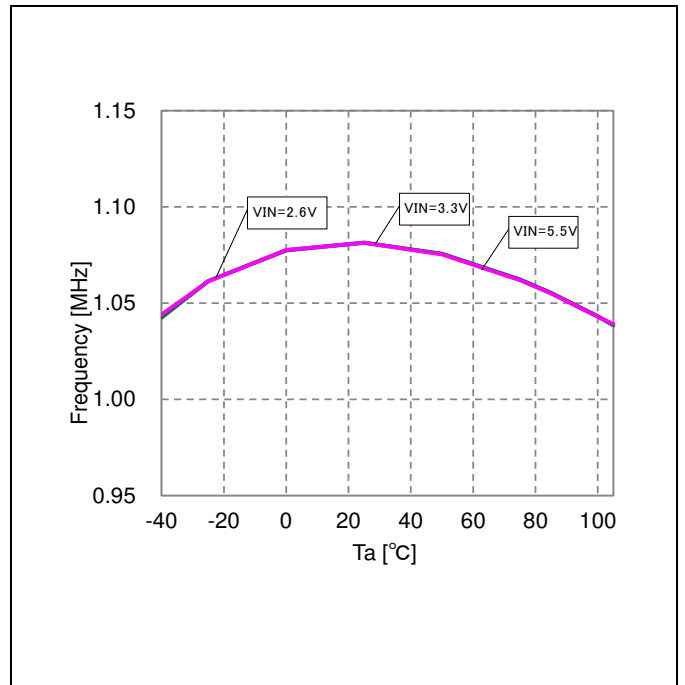


Figure 6. Switching Frequency (Dependent on temperature)

Typical Performance Curves - continued

(Unless otherwise specified VIN=3.3V, VDD=2.5V, AVDD=10.5V, VGH=18V, VGL=-6.0V, VCOM=5.25V and Ta=25°C)

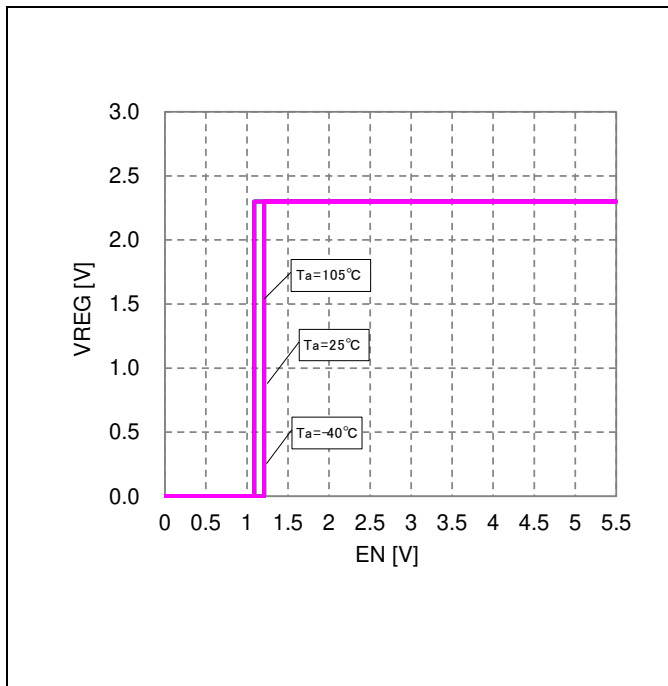


Figure 7. H/L threshold voltage (control signals)

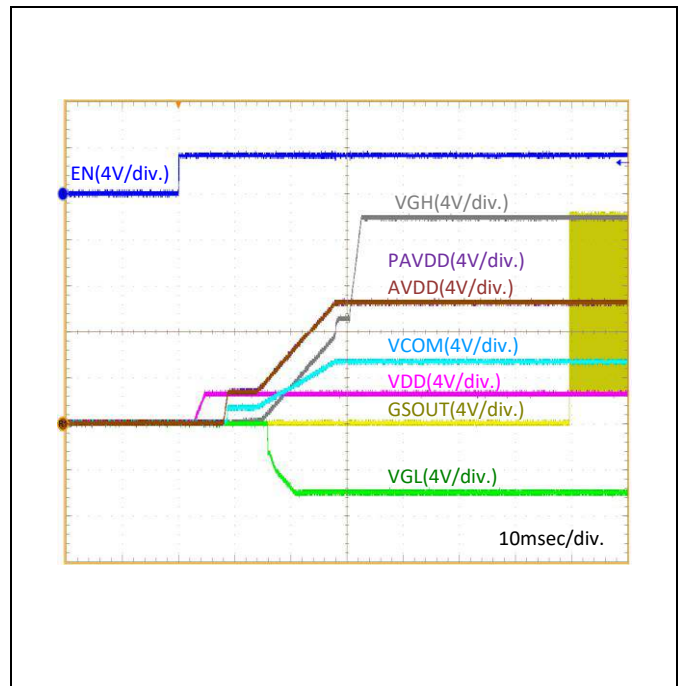


Figure 8. Power on waveform (when operated by EN control, Function select = PG)

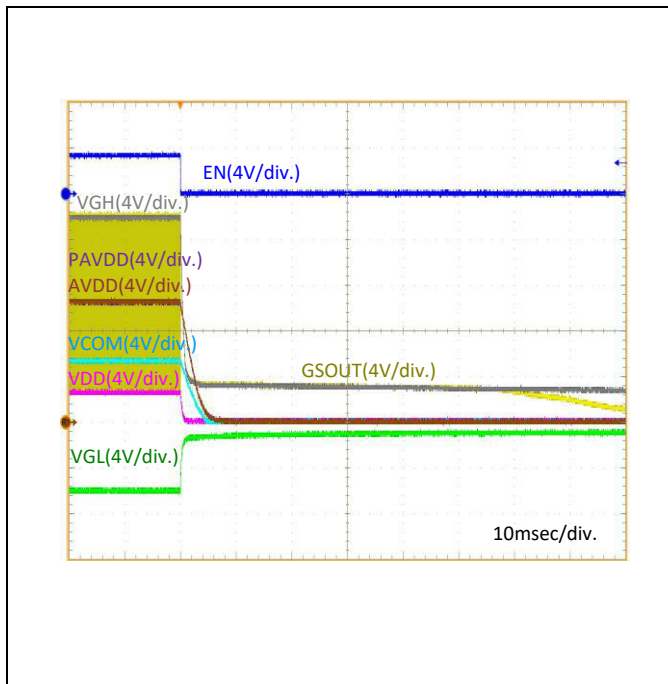


Figure 9. Power off waveform (when operated by EN control, Function select = PG)

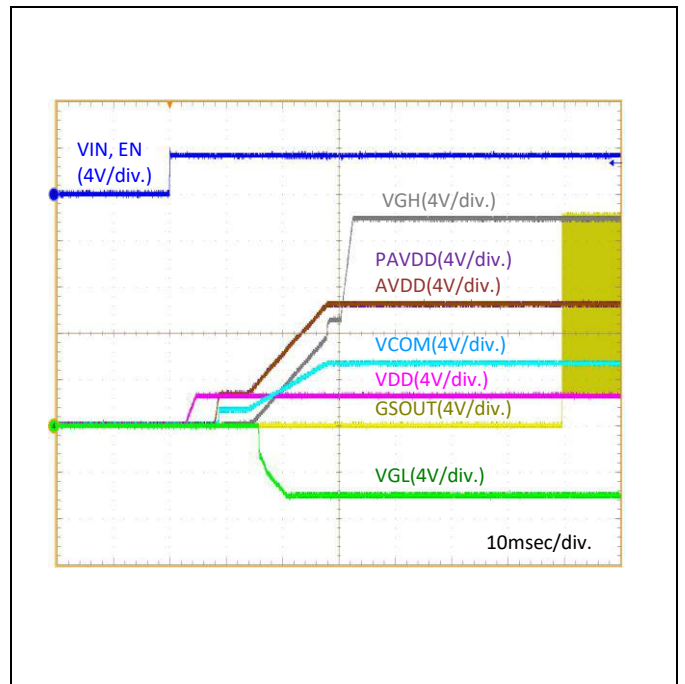


Figure 10. Power on waveform (when operated with EN=VCC, Function select = PG)

Typical Performance Curves - continued

(Unless otherwise specified VIN=3.3V, VDD=2.5V, AVDD=10.5V, VGH=18V, VGL=-6.0V, VCOM=5.25V and Ta=25°C)

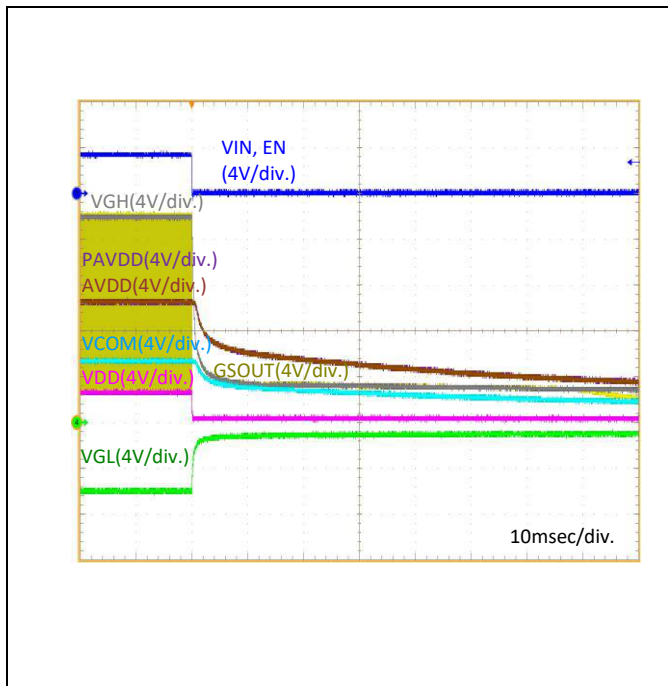


Figure 11. Power off waveform (when operated with EN=VCC, Function select = PG)

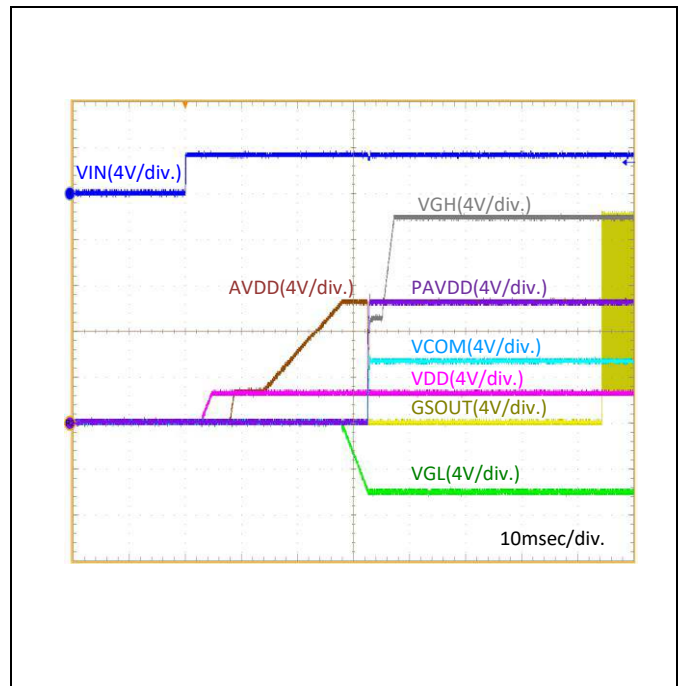


Figure 12. Power on waveform (when operated by EN control, Function select = LDSW)

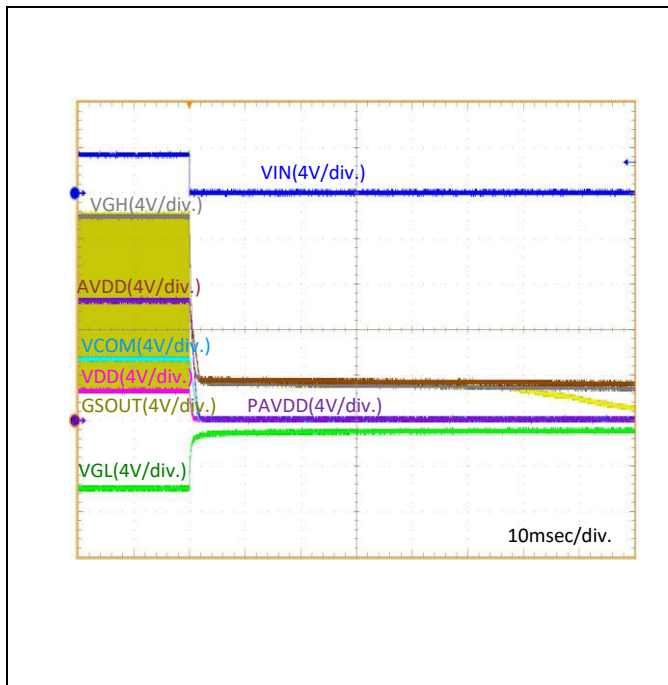


Figure 13. Power off waveform (when operated by EN control, Function select = LDSW)

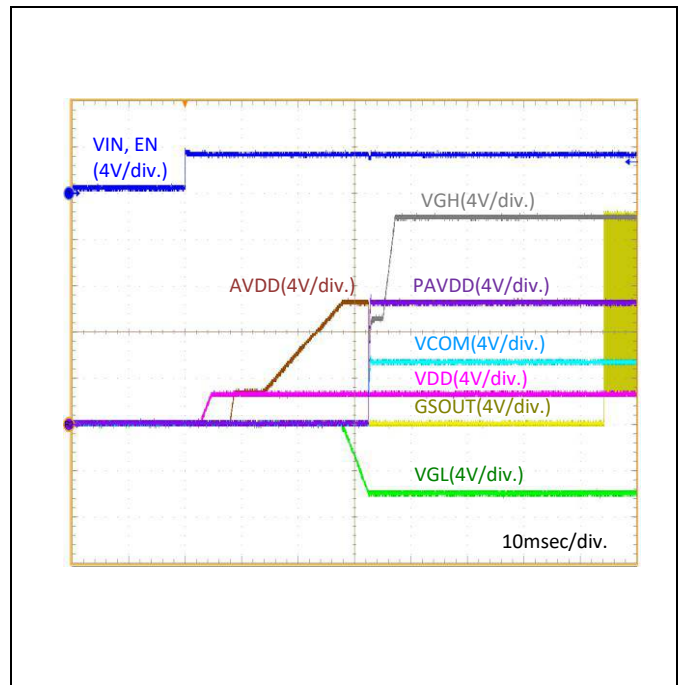


Figure 14. Power on waveform (when operated with EN=VCC, Function select = LDSW)

Typical Performance Curves - continued

(Unless otherwise specified VIN=3.3V, VDD=2.5V, AVDD=10.5V, VGH=18V, VGL=-6.0V, VCOM=5.25V and Ta=25°C)

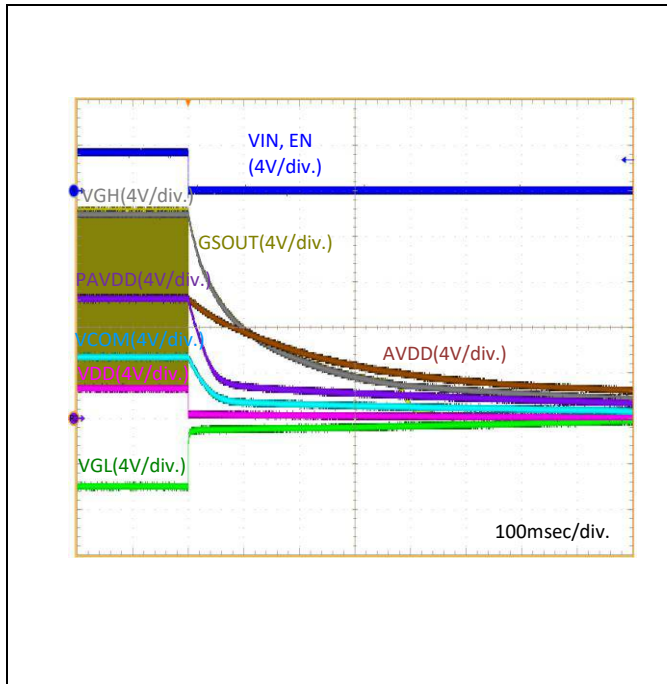


Figure 15. Power off waveform (when operated with EN=VCC, Function select = LDSW)

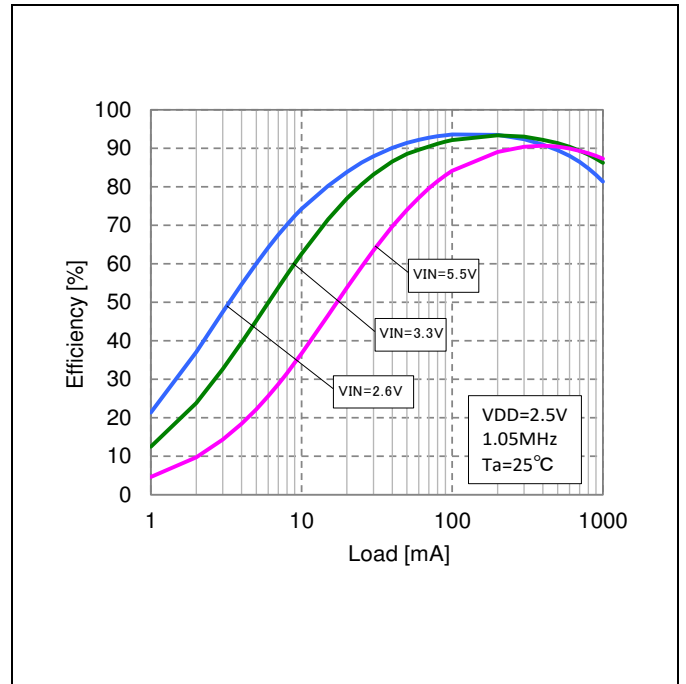


Figure 16. Efficiency (VDD DC/DC mode)

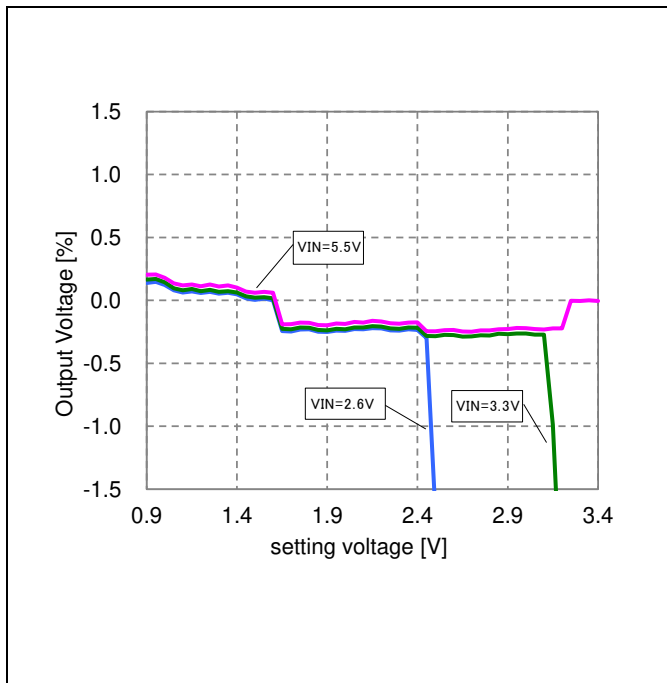


Figure 17. Output voltage accuracy (VDD DC/DC mode, dependent on input voltage)

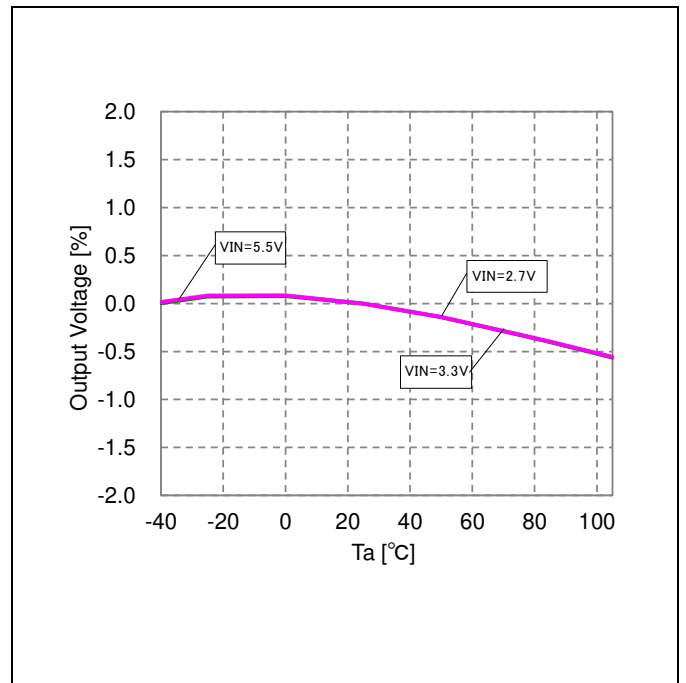


Figure 18. Output voltage accuracy (VDD DC/DC mode, dependent on temperature)

Typical Performance Curves - continued

(Unless otherwise specified VIN=3.3V, VDD=2.5V, AVDD=10.5V, VGH=18V, VGL=-6.0V, VCOM=5.25V and Ta=25°C)

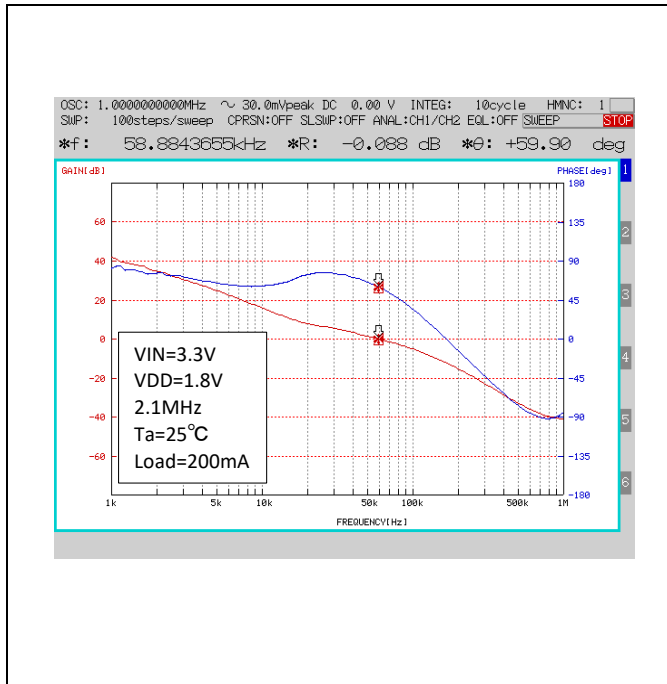


Figure 19. Phase margin (VDD DC/DC mode)

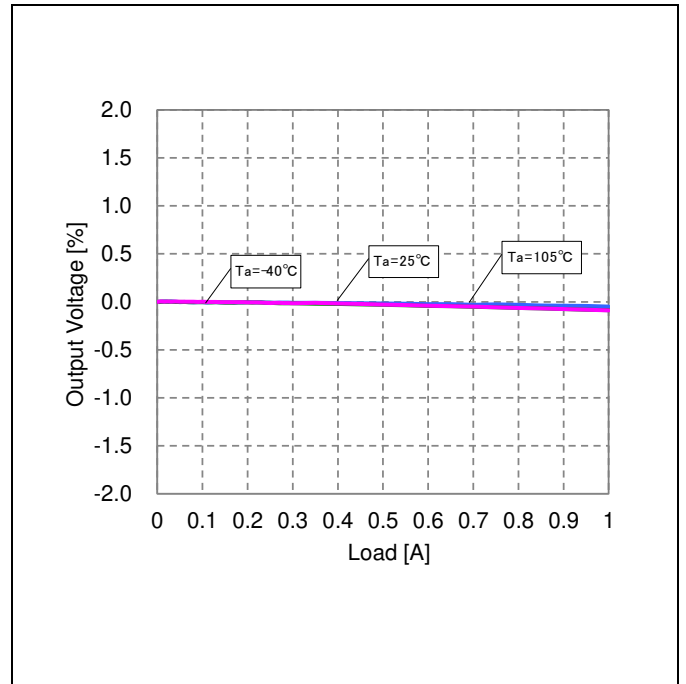


Figure 20. Load Regulation (VDD DC/DC mode)

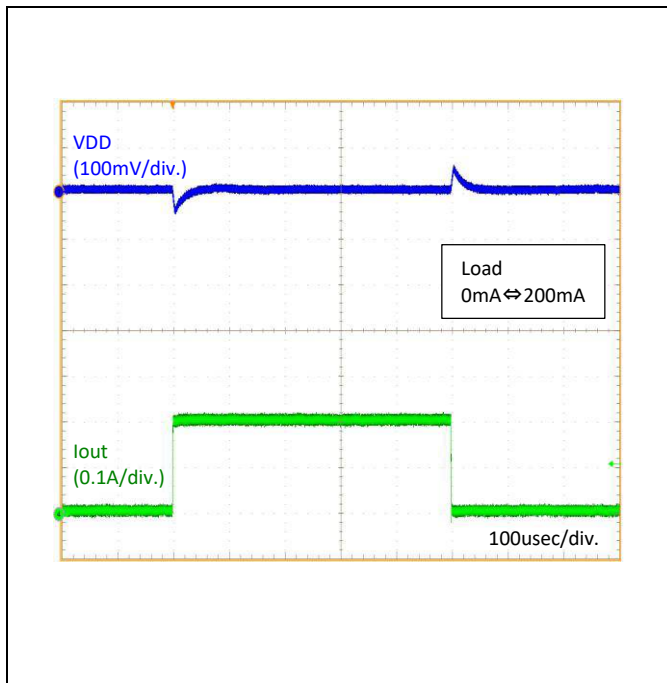


Figure 21. Load Transient (VDD DC/DC mode)

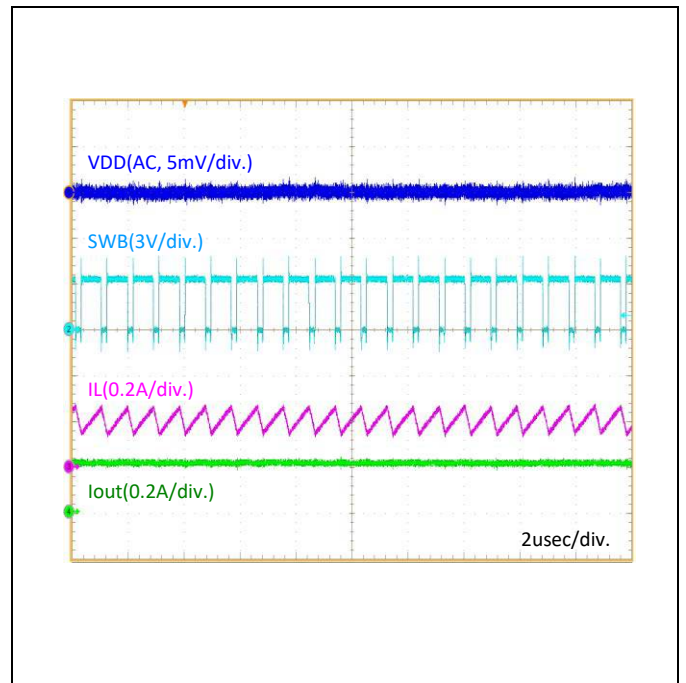


Figure 22. Switching waveform (VDD DC/DC mode)

Typical Performance Curves - continued

(Unless otherwise specified VIN=3.3V, VDD=2.5V, AVDD=10.5V, VGH=18V, VGL=-6.0V, VCOM=5.25V and Ta=25°C)

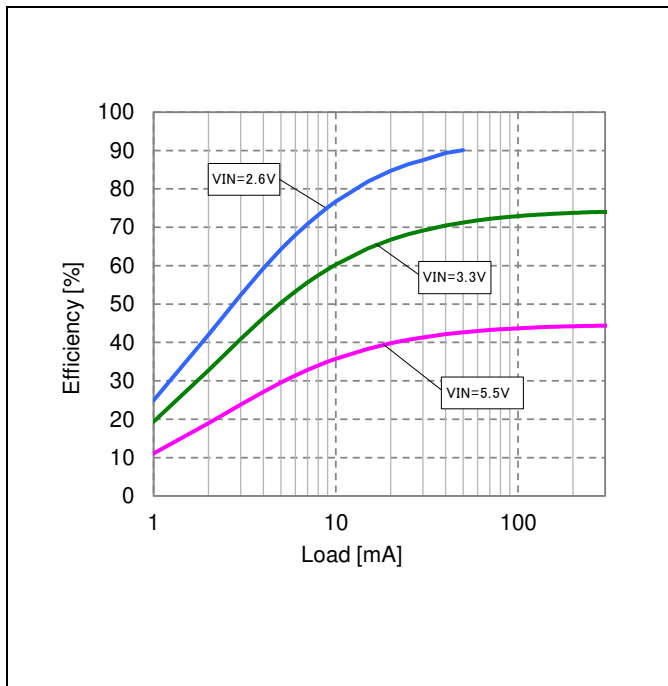


Figure 23. Efficiency (VDD LDO mode)

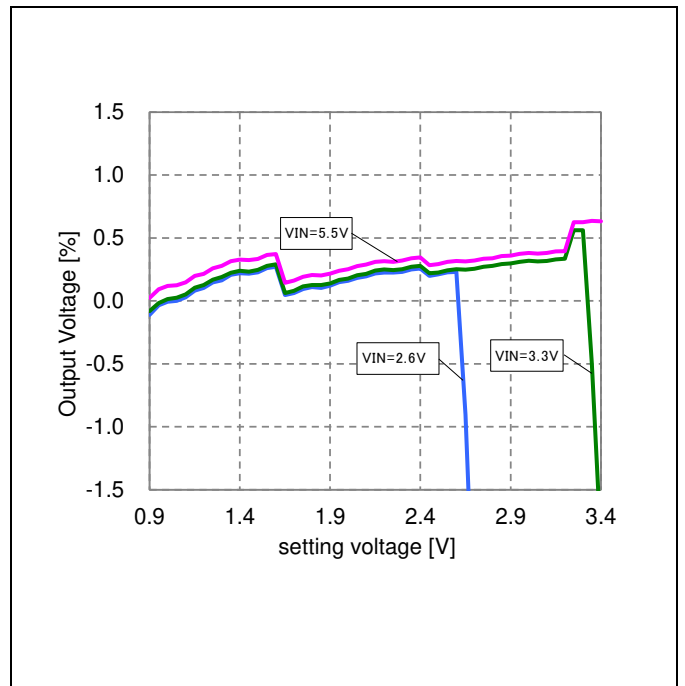


Figure 24. Output voltage accuracy (VDD LDO mode, dependent on input voltage)

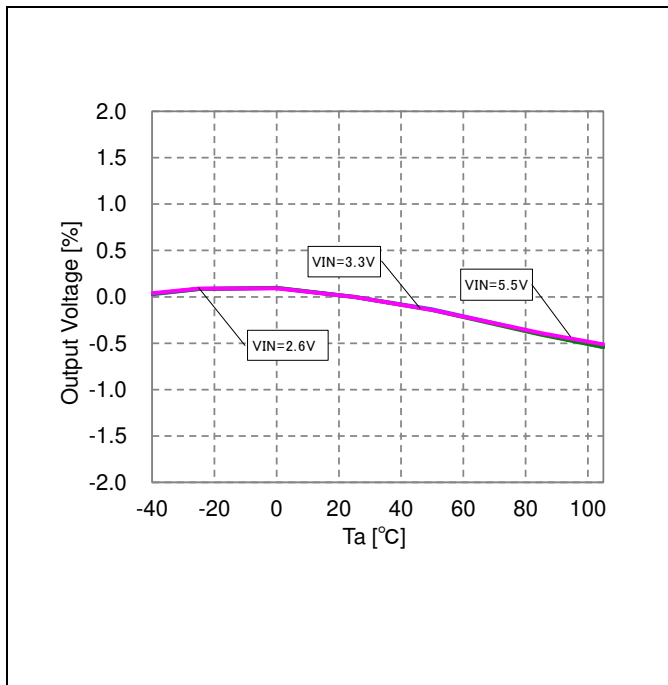


Figure 25. Output voltage accuracy (VDD LDO mode, dependent on temperature)

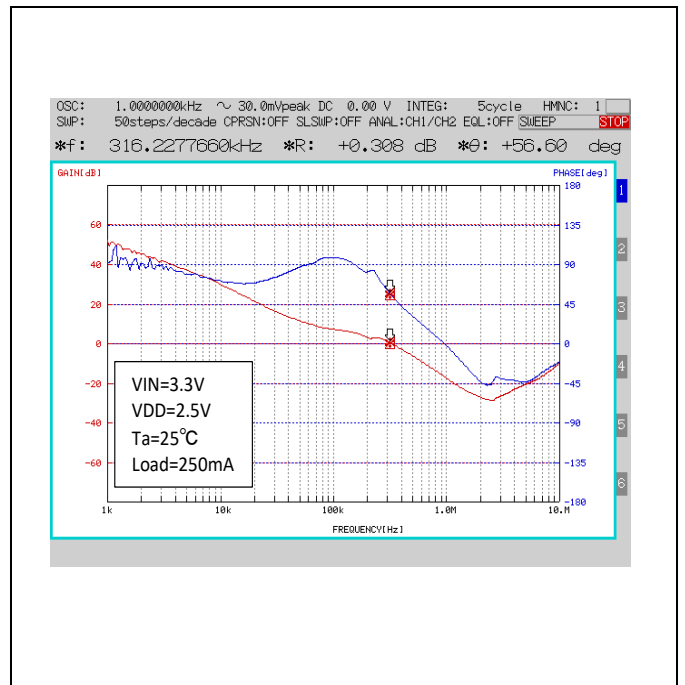


Figure 26. Phase margin (VDD LDO mode)

Typical Performance Curves - continued

(Unless otherwise specified VIN=3.3V, VDD=2.5V, AVDD=10.5V, VGH=18V, VGL=-6.0V, VCOM=5.25V and Ta=25°C)

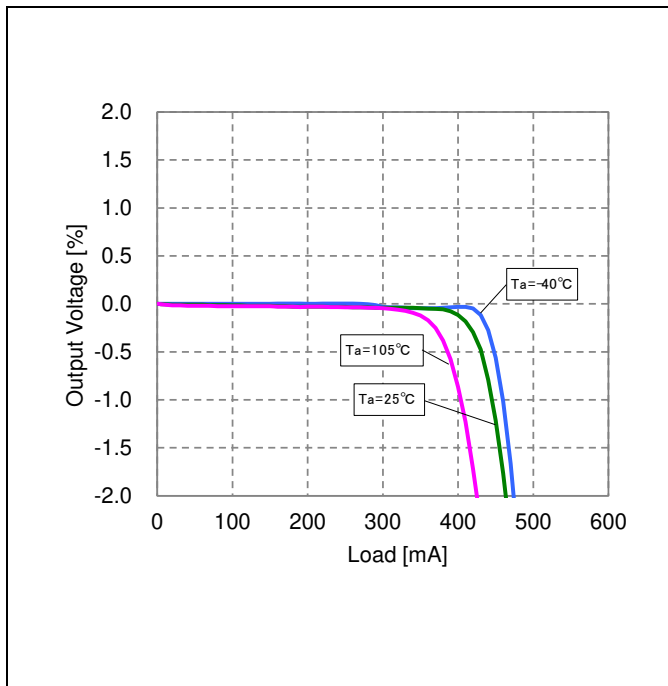


Figure 27. Load Regulation (VDD LDO mode)

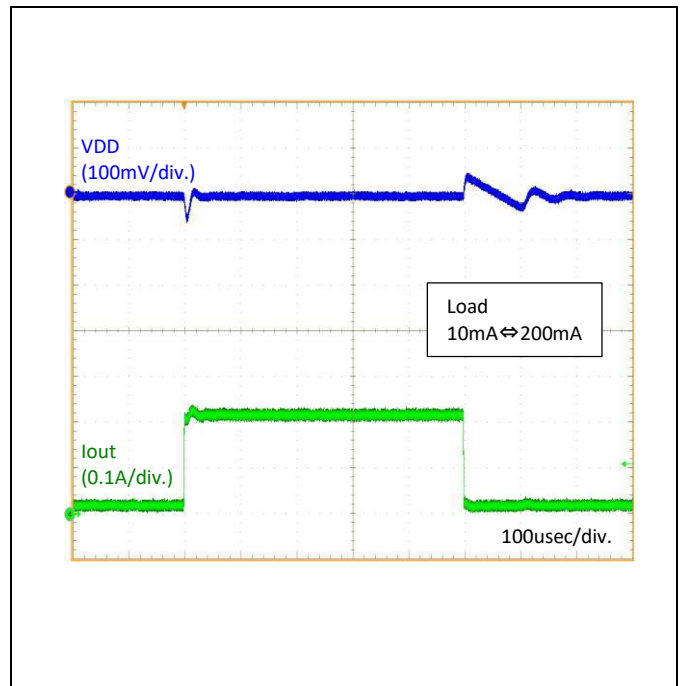


Figure 28. Load Transient (VDD LDO mode)

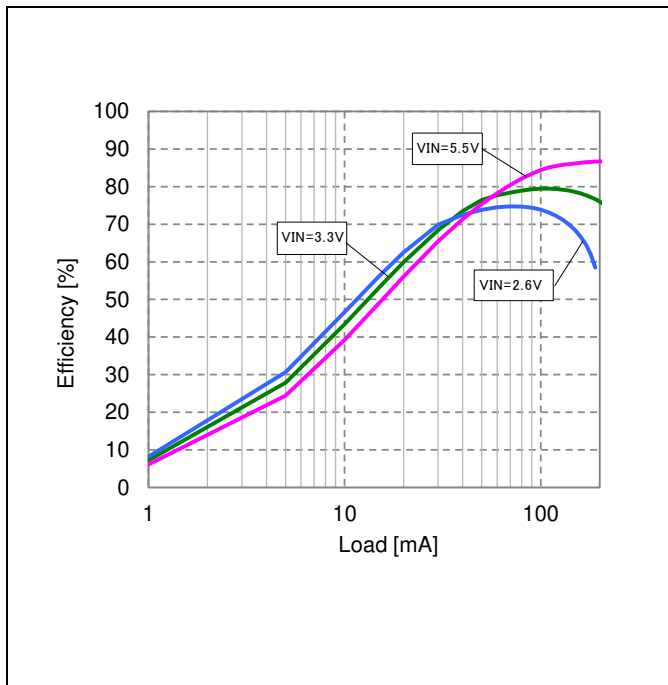


Figure 29. Efficiency (AVDD)

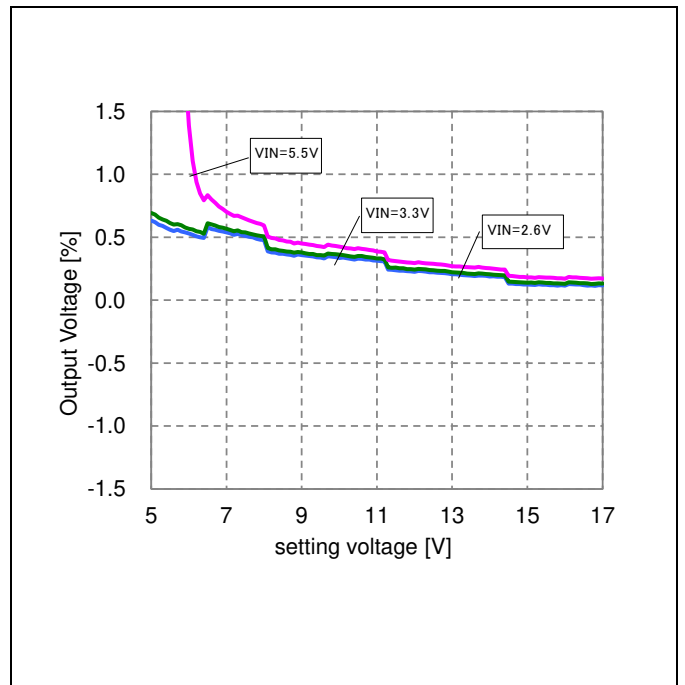


Figure 30. Output voltage accuracy (AVDD, dependent on input voltage)



Typical Performance Curves - continued

(Unless otherwise specified VIN=3.3V, VDD=2.5V, AVDD=10.5V, VGH=18V, VGL=-6.0V, VCOM=5.25V and Ta=25°C)

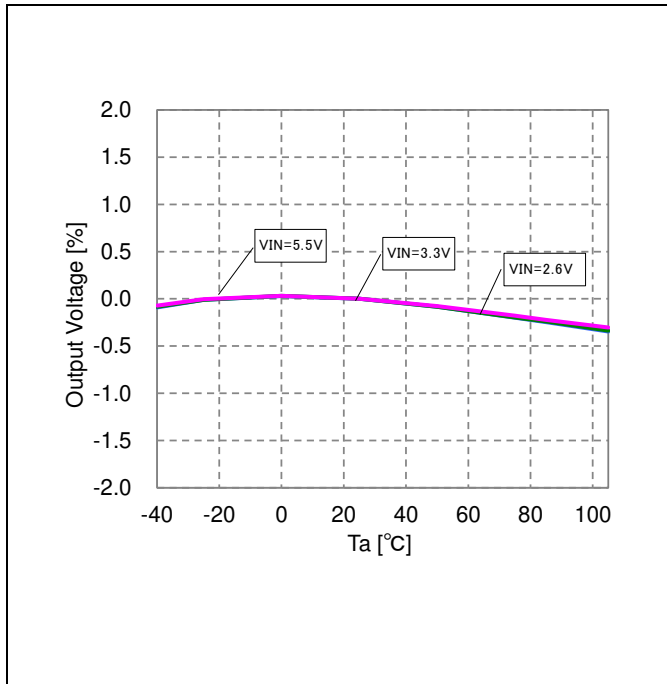


Figure 31. Output voltage accuracy (AVDD, dependent on temperature)

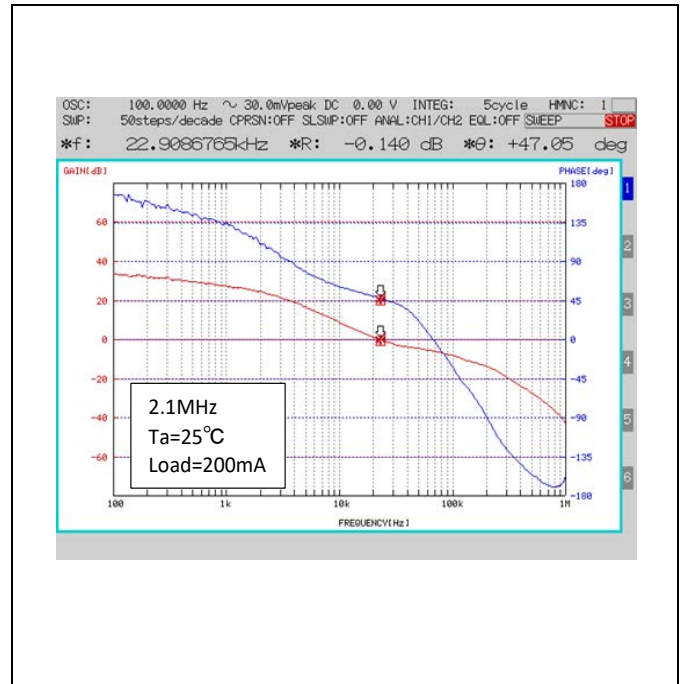


Figure 32. Phase margin (AVDD)

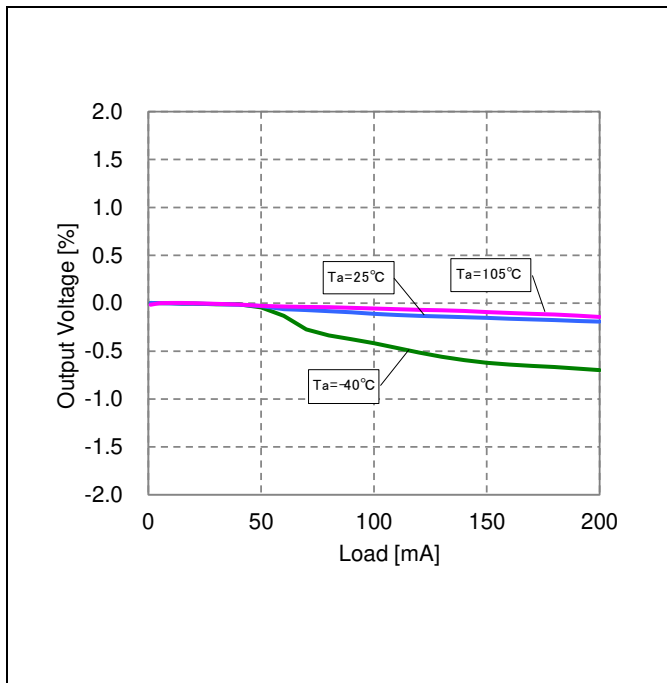


Figure 33. Load Regulation (AVDD)

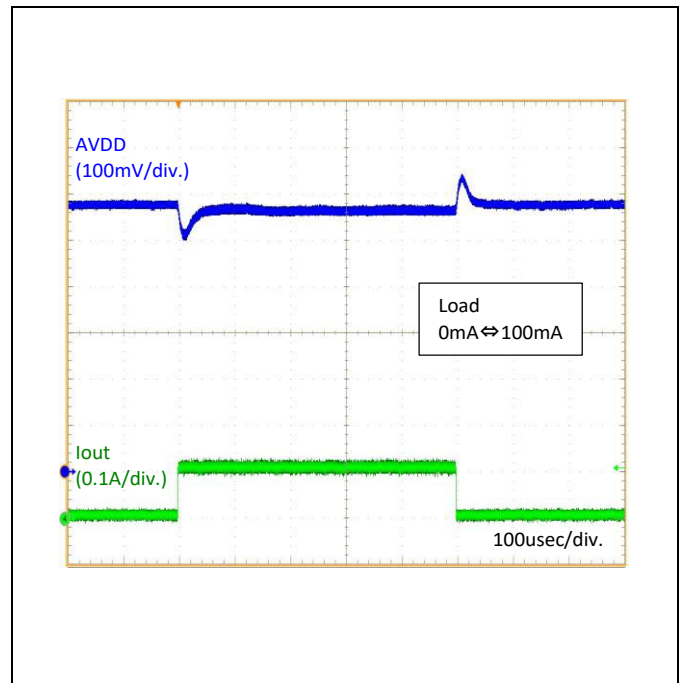


Figure 34. Load Transient (AVDD)

Typical Performance Curves - continued

(Unless otherwise specified VIN=3.3V, VDD=2.5V, AVDD=10.5V, VGH=18V, VGL=-6.0V, VCOM=5.25V and Ta=25°C)

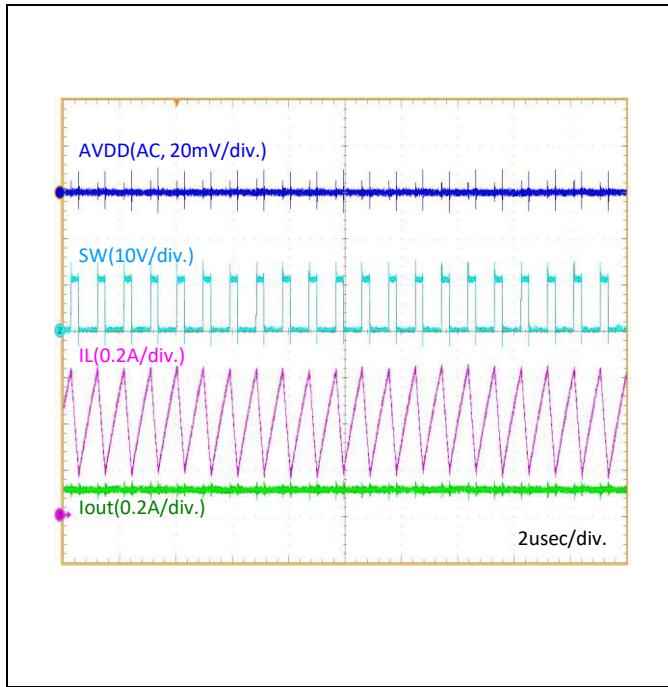


Figure 35. Switching waveform (AVDD)

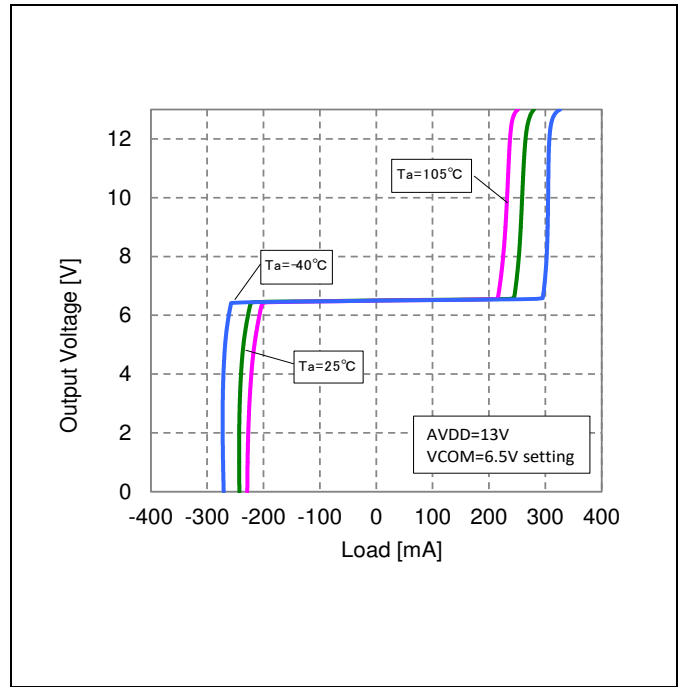


Figure 36. Output Current (VCOM)

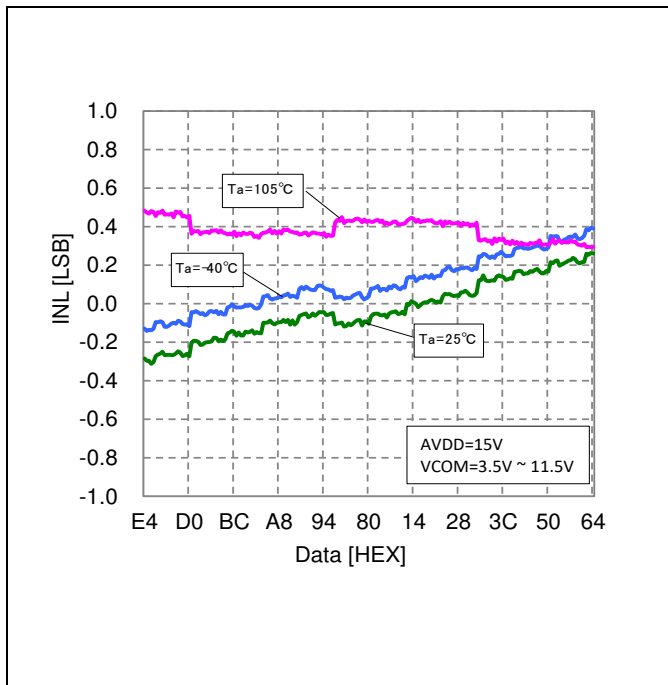


Figure 37. DAC INL (VCOM)

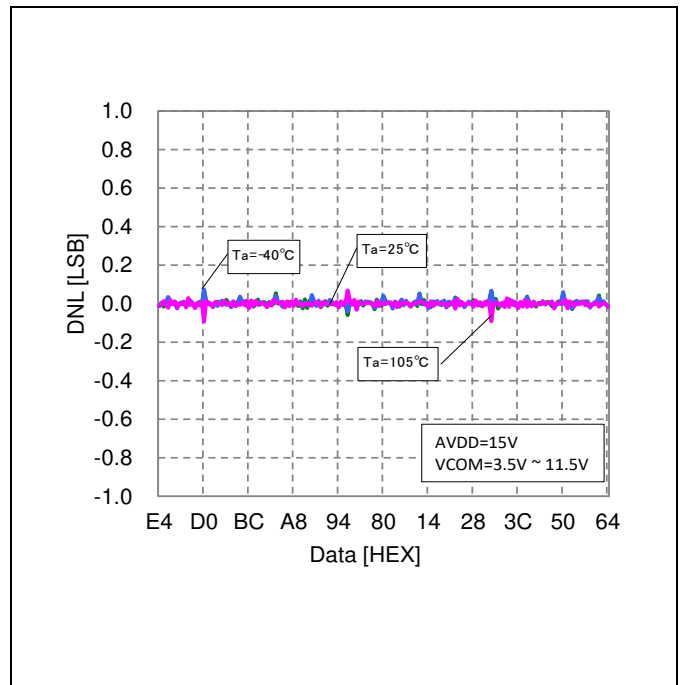


Figure 38. DAC DNL (VCOM)

Typical Performance Curves - continued

(Unless otherwise specified VIN=3.3V, VDD=2.5V, AVDD=10.5V, VGH=18V, VGL=-6.0V, VCOM=5.25V and Ta=25°C)

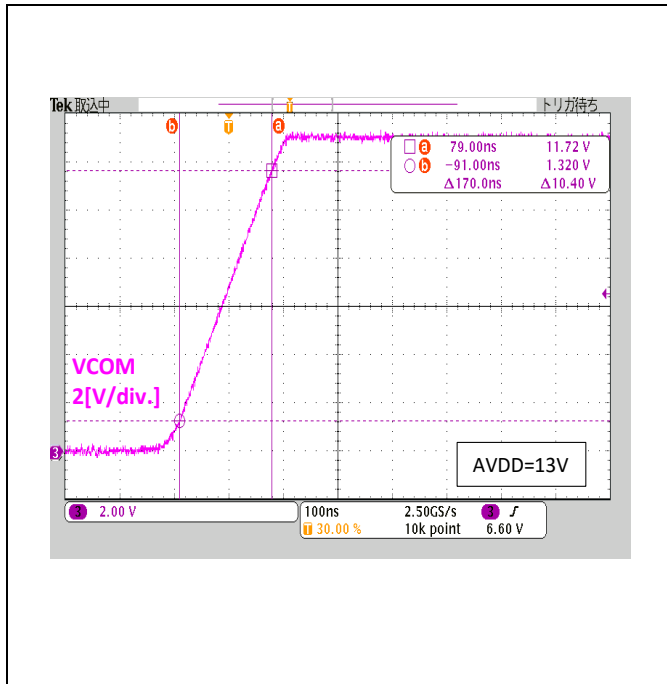


Figure 39. Slew Rate (VCOM, rise)

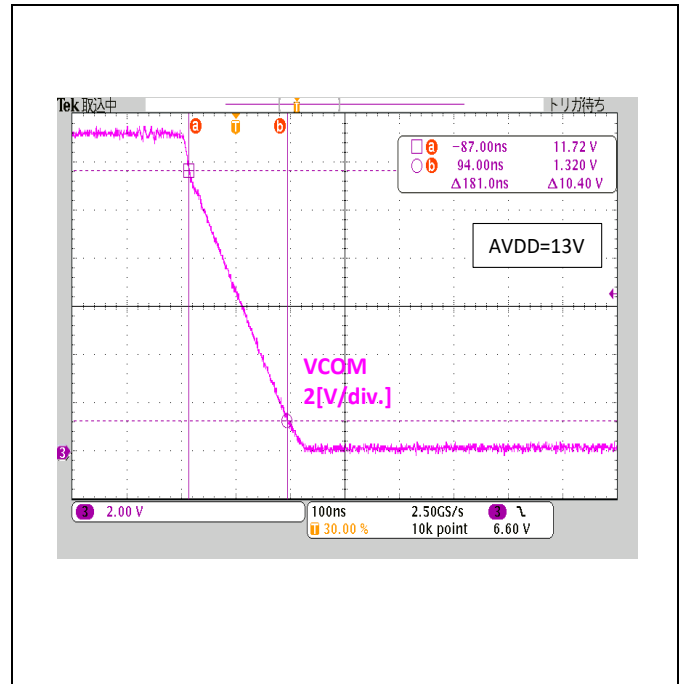


Figure 40. Slew Rate (VCOM, fall)

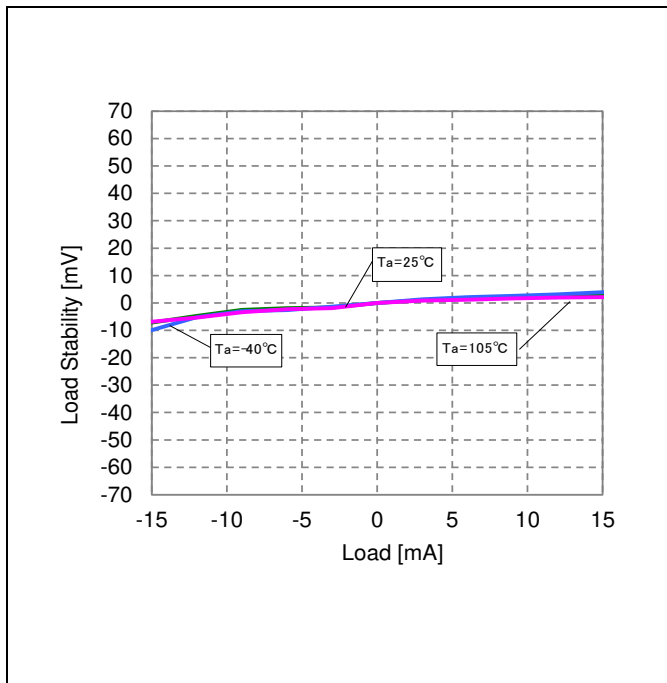


Figure 41. Load Regulation (VCOM)

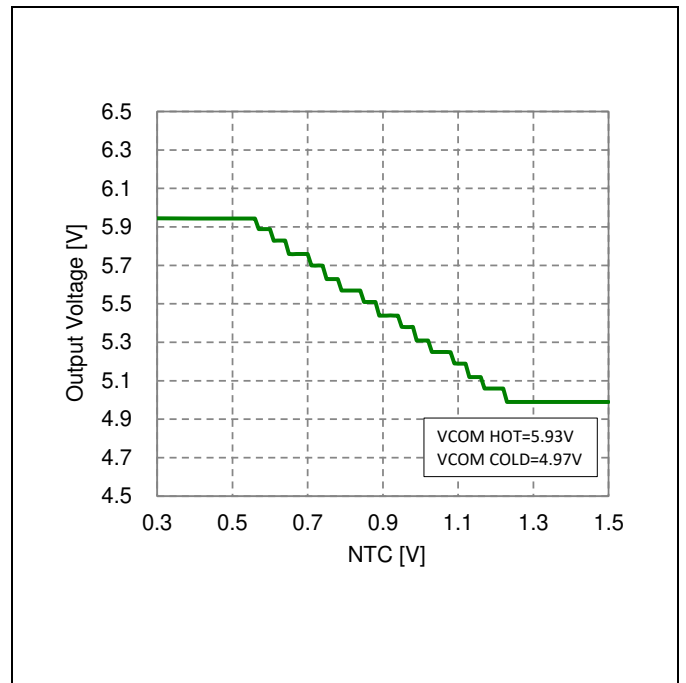


Figure 42. NTC Function (VCOM)

Typical Performance Curves - continued

(Unless otherwise specified VIN=3.3V, VDD=2.5V, AVDD=10.5V, VGH=18V, VGL=-6.0V, VCOM=5.25V and Ta=25°C)

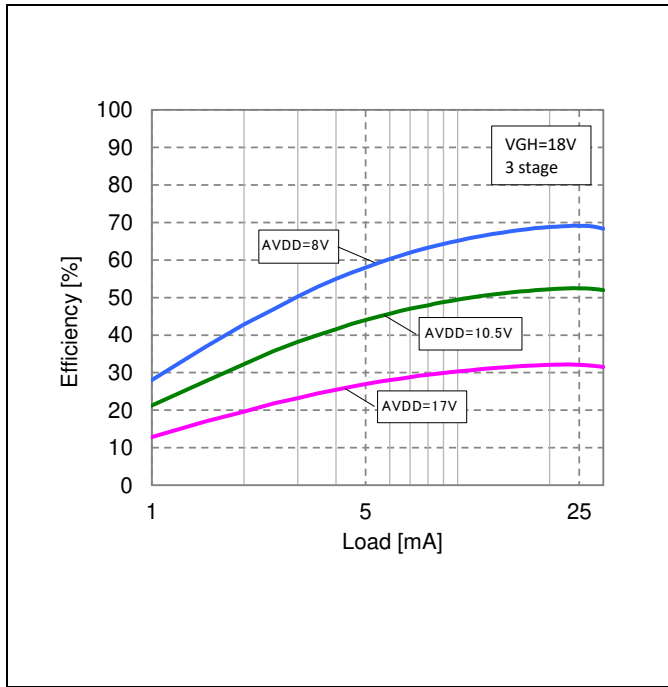


Figure 43. Efficiency (VGH)

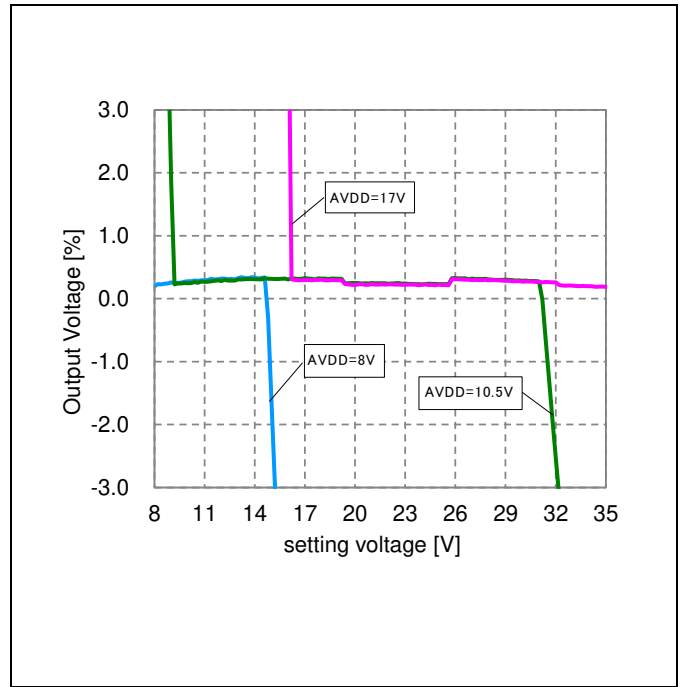


Figure 44. Output voltage accuracy (VGH, dependent on input voltage)

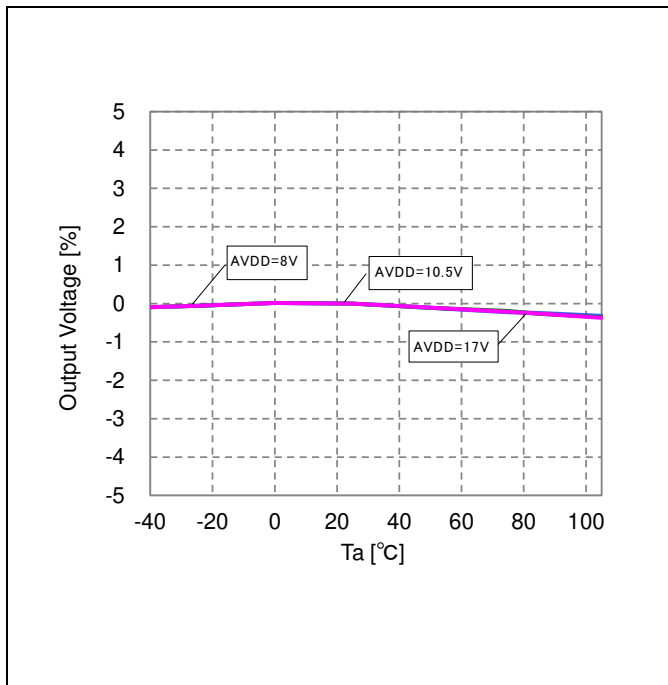


Figure 45. Output voltage accuracy (VGH, dependent on temperature)

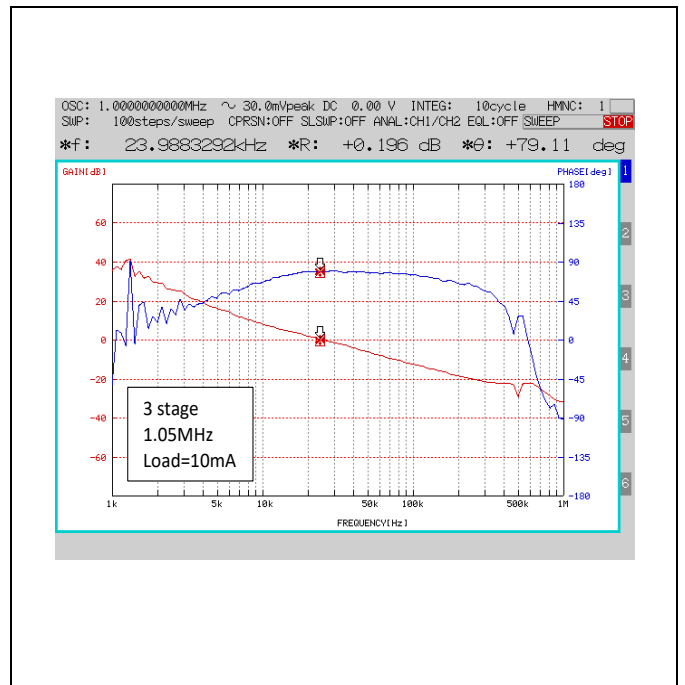


Figure 46. Phase margin (VGH)

Typical Performance Curves - continued

(Unless otherwise specified VIN=3.3V, VDD=2.5V, AVDD=10.5V, VGH=18V, VGL=-6.0V, VCOM=5.25V and Ta=25°C)

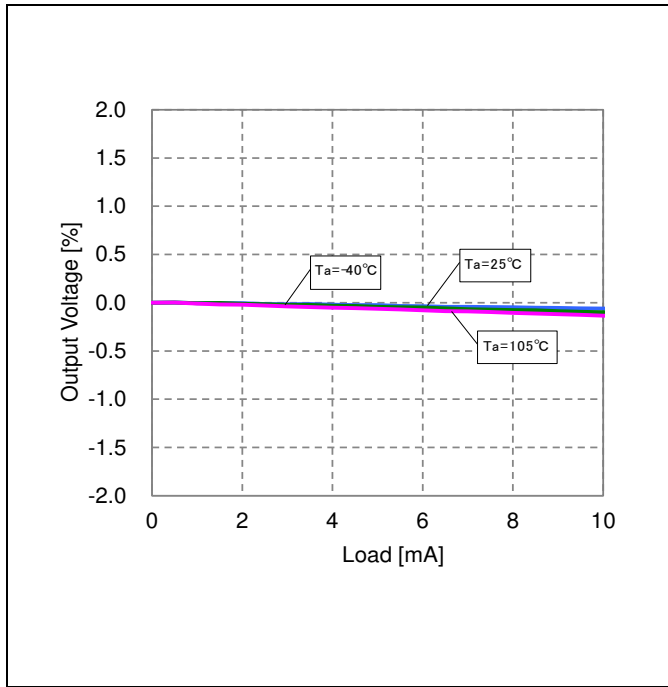


Figure 47. Load Regulation (VGH)

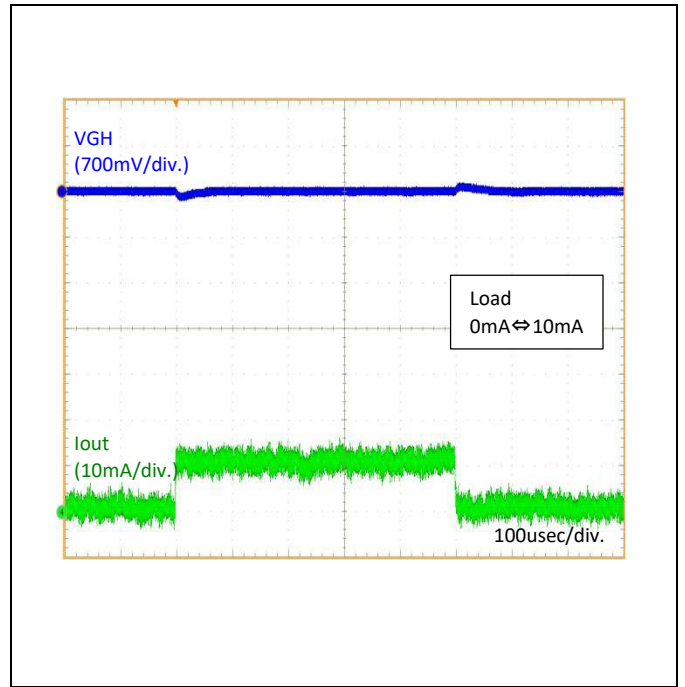


Figure 48. Load Transient (VGH)

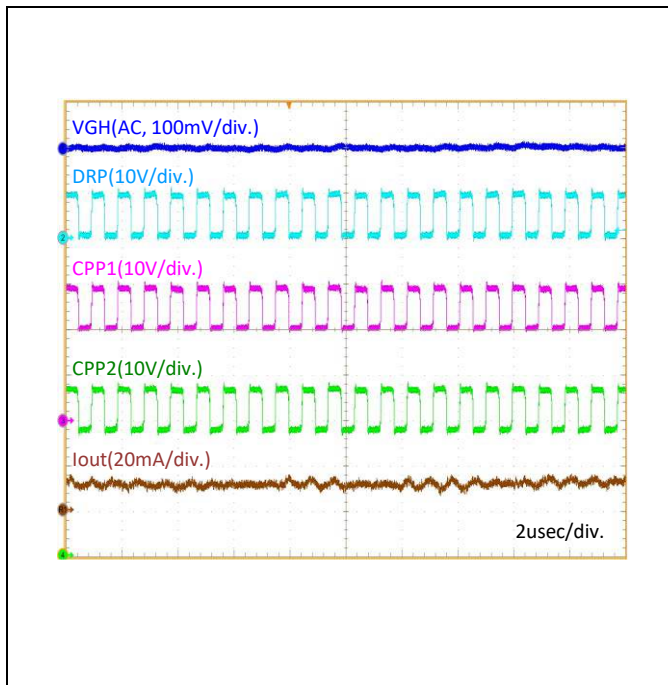


Figure 49. Switching waveform (VGH)

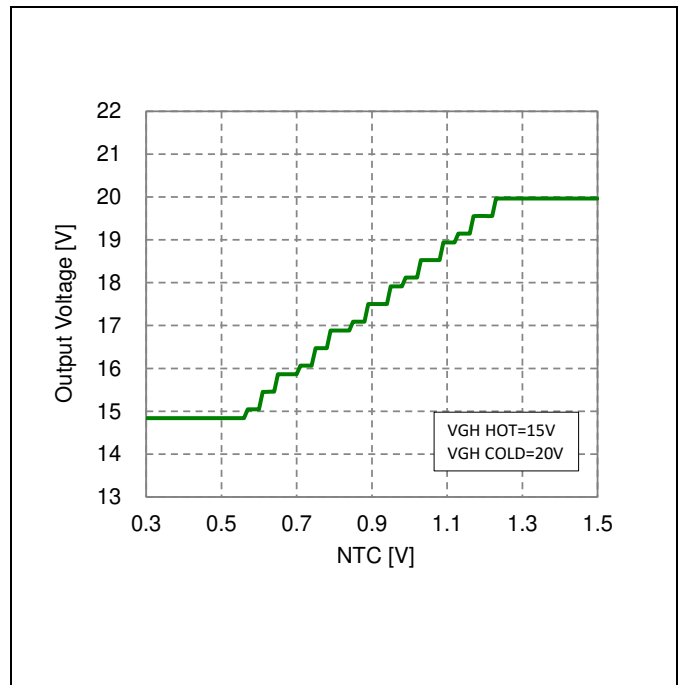


Figure 50. NTC Function (VGH)

Typical Performance Curves - continued

(Unless otherwise specified VIN=3.3V, VDD=2.5V, AVDD=10.5V, VGH=18V, VGL=-6.0V, VCOM=5.25V and Ta=25°C)

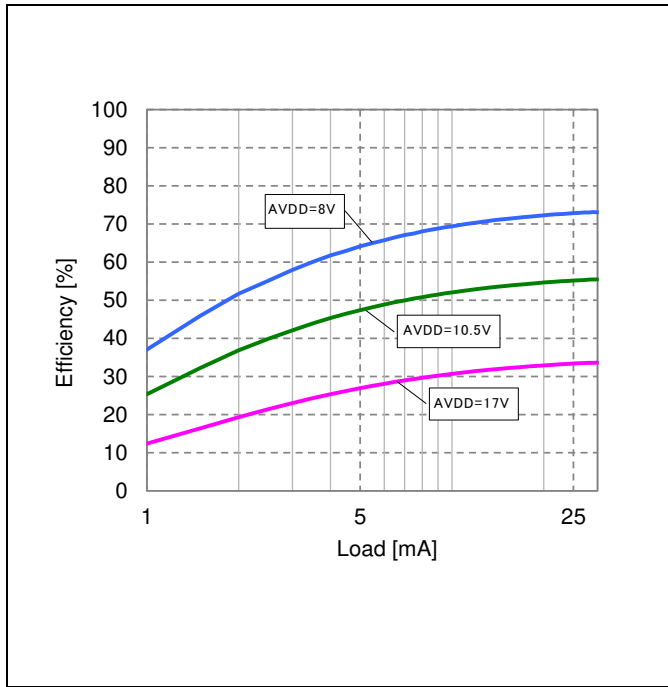


Figure 51. Efficiency (VGL)

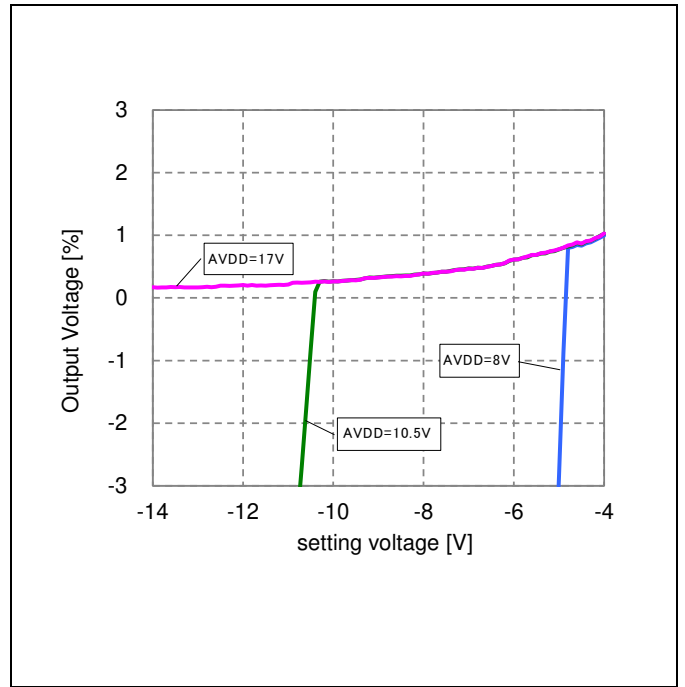


Figure 52. Output voltage accuracy (VGL, dependent on input voltage)

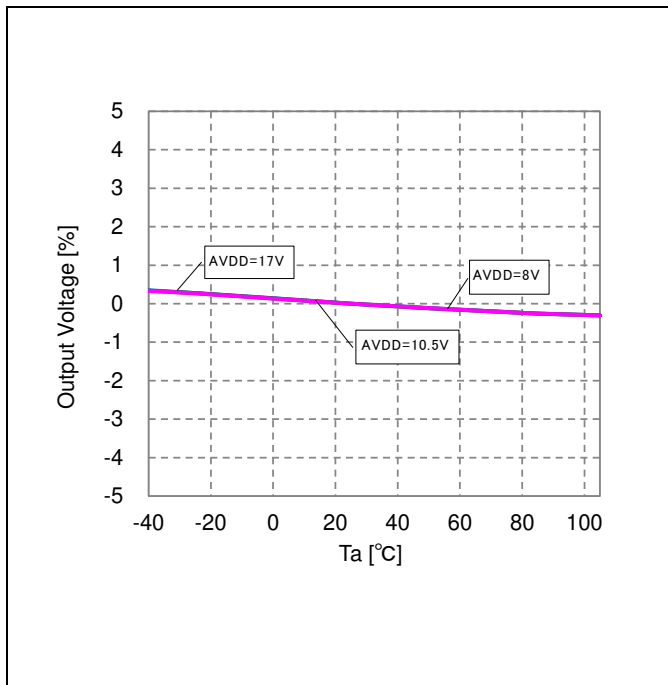


Figure 53. Output voltage accuracy (VGL, dependent on temperature)

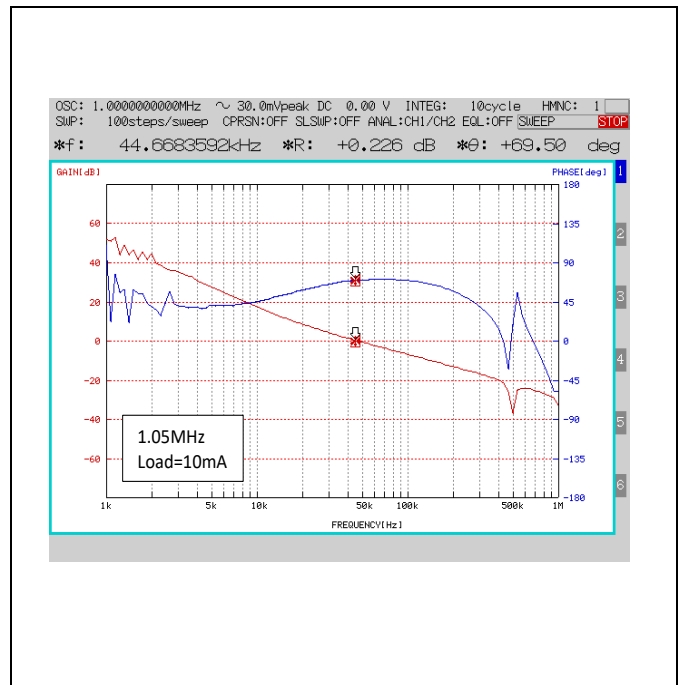


Figure 54. Phase margin (VGL)

Typical Performance Curves - continued

(Unless otherwise specified VIN=3.3V, VDD=2.5V, AVDD=10.5V, VGH=18V, VGL=-6.0V, VCOM=5.25V and Ta=25°C)

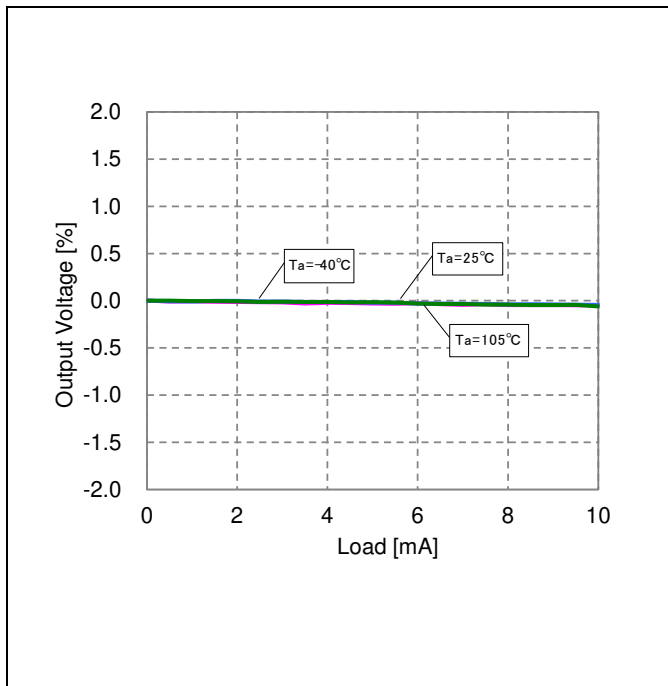


Figure 55. Load Regulation (VGL)

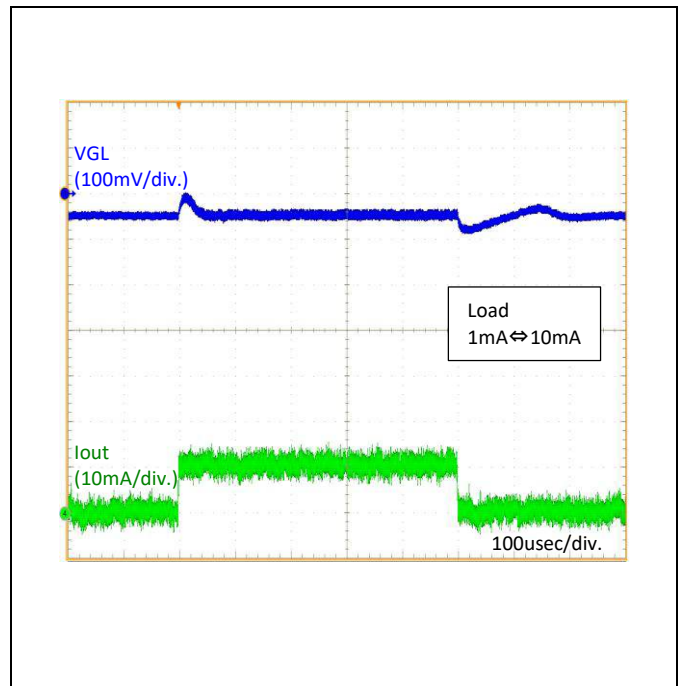


Figure 56. Load Transient (VGL)

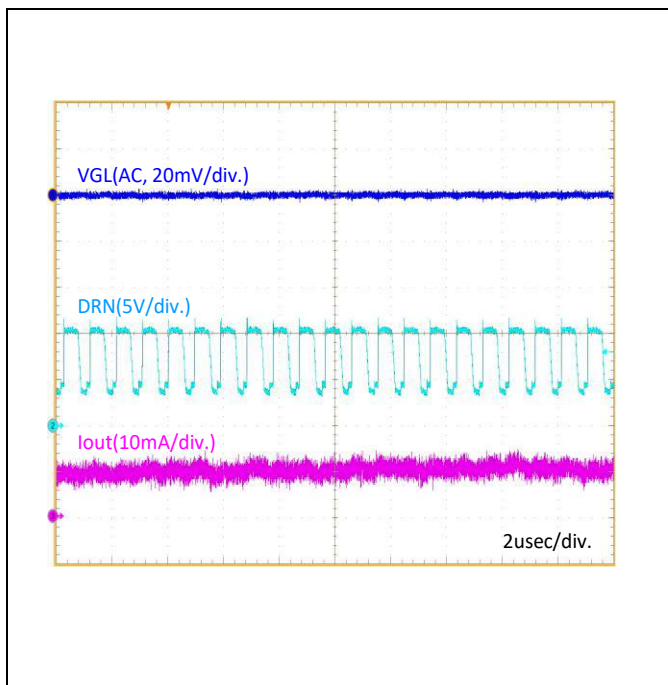


Figure 57. Switching waveform (VGL)

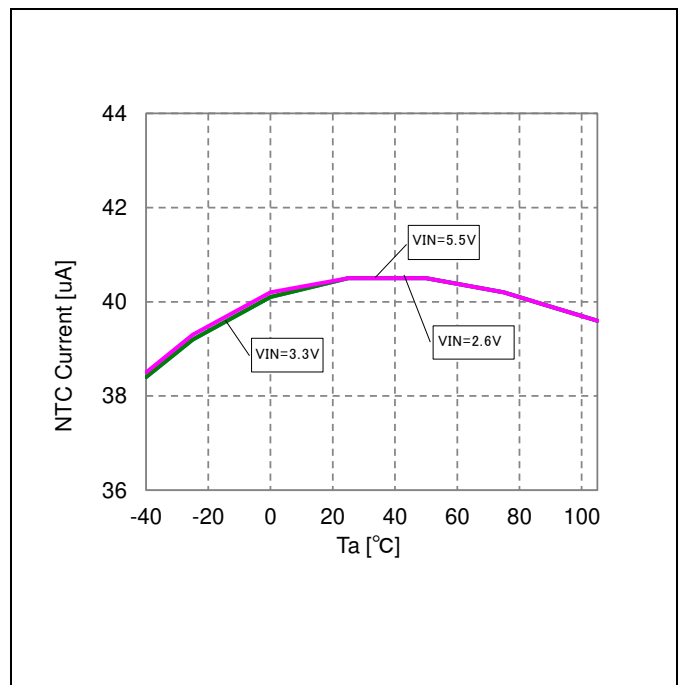


Figure 58. NTC current

Typical Performance Curves - continued

(Unless otherwise specified VIN=3.3V, VDD=2.5V, AVDD=10.5V, VGH=18V, VGL=-6.0V, VCOM=5.25V and Ta=25°C)

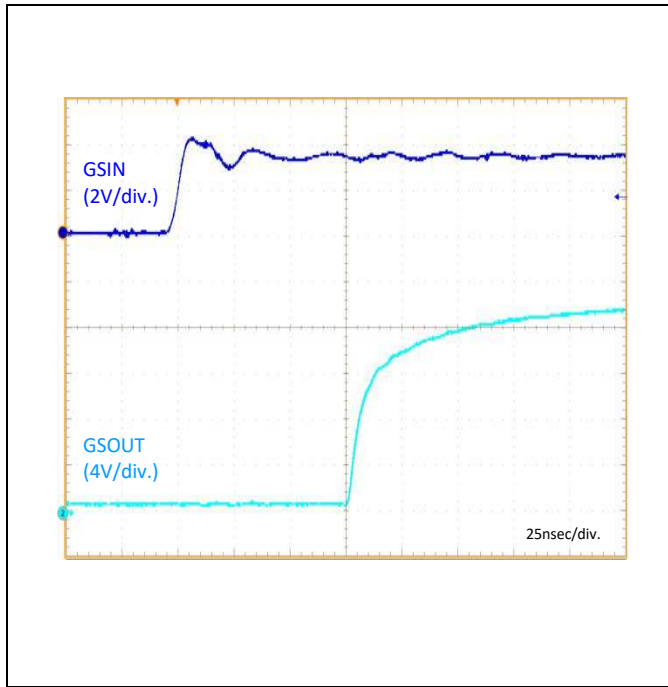


Figure 59. Propagation Delay (GPM, rise)

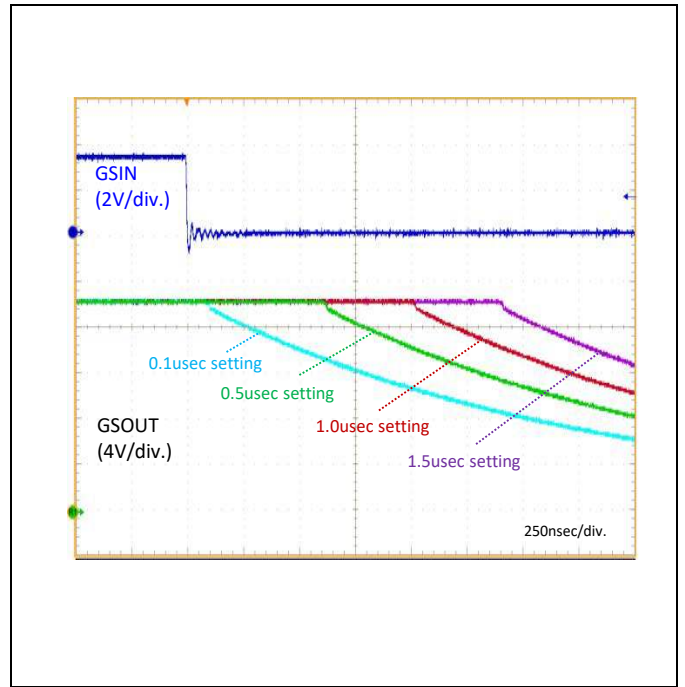


Figure 60. Propagation Delay (GPM, fall)

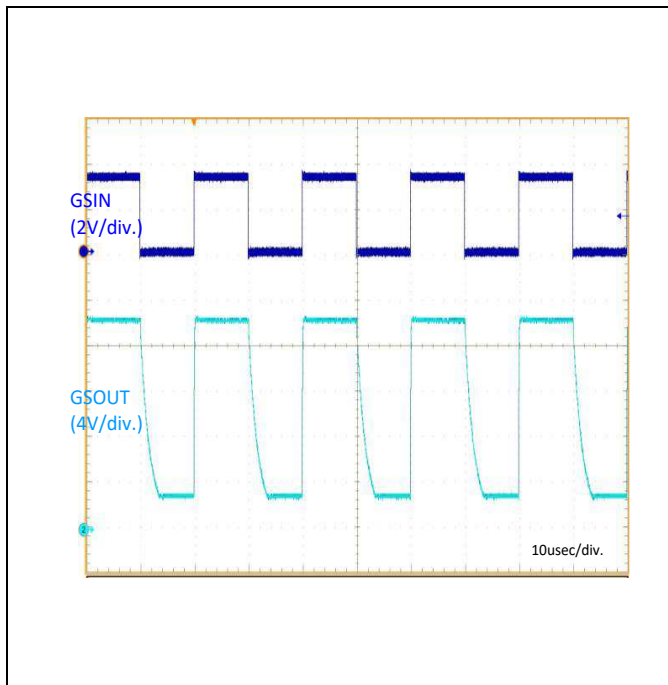


Figure 61. Waveform (GPM)



Application Example 1 (when operated by EN control)

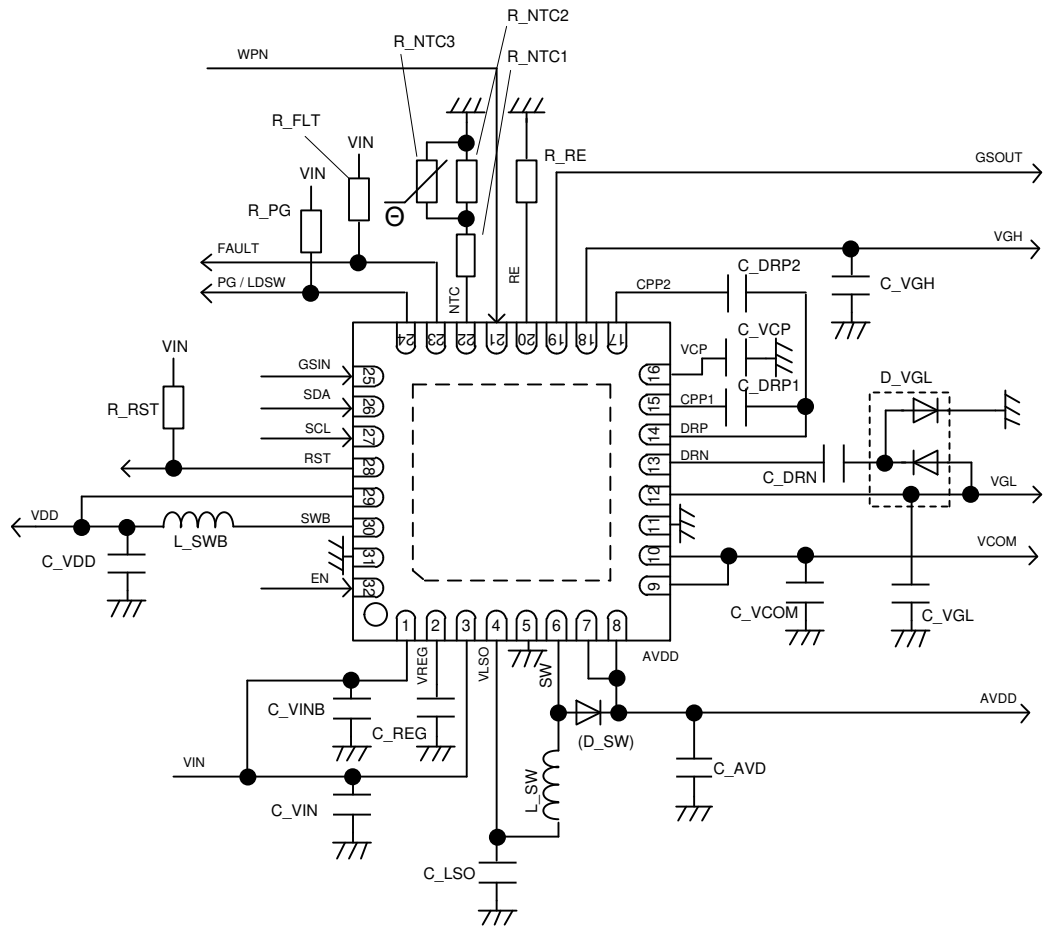


Figure 62. Application Circuit  
(Function Select = PG)

## Application Example 1 (when operated by EN control) – continued

## Application circuit components list

(Unless otherwise specified VIN=3.3V, VDD=2.5V, AVDD=10.5V, VGH=18V, VGL=-6.0V, VCOM=5.25V)

| Parts name | Value           |        |        | Unit | Company | Parts Number       | Comment  |
|------------|-----------------|--------|--------|------|---------|--------------------|--|
|            | Min<br>(Note 1) | Typ    | Max    |      |         |                    |  |
| C_VIN      | 10              | 10 x 2 | -      | μF   | MURATA  | GRT21BC81A106KE01  |  |
| C_VINB     | 4.7             | 10     | -      | μF   | MURATA  | GRT21BC81A106KE01  | No need @ VDD LDO mode   |
| C_REG      | 0.047           | 0.1    | 0.47   | μF   | MURATA  | GRT188R71H104KE13  |  |
| C_LSO      | 10              | 10 x 2 | -      | μF   | MURATA  | GRT21BC81A106KE01  |  |
| C_AVD      | 5.0             | 10 x 3 | 10 x 6 | μF   | MURATA  | GRT31CC81E106KE01  | See p.49 in detail.  |
| L_SW       | -               | 4.7    | -      | μH   | TDK     | LTF5022T-4R7N2R0-H | See p.49 in detail.  |
| D_SW       | -               | -      | -      | -    | ROHM    | (RB060M-30DD)      | Please insert D_SW when improving the efficiency is necessary. |
| C_VDD      | 10              | 10 x 2 | 47     | μF   | MURATA  | GRT21BC81A106KE01  |  |
| L_SWB      | -               | 4.7    | -      | μH   | TDK     | LTF5022T-4R7N2R0-H |  |
| C_VCOM     | -               | -      | -      | μF   | MURATA  | -                  |  |
| C_VGL      | 0.47            | 1.0    | 4.7    | μF   | MURATA  | GRT21BC81E105KE13  |  |
| C_DRN      | -               | 0.1    | -      | μF   | MURATA  | GRT188R71H104KE13  |  |
| D_VGL      |                 | -      |        | -    | ROHM    | RB558WFH           |  |
| C_VGH      | 0.47            | 2.2    | 4.7    | μF   | MURATA  | GRT21BC8YA225KE13  |  |
| C_CPP1     | -               | 0.1    | -      | μF   | MURATA  | GRT188R71H104KE13  |  |
| C_VCP      | -               | 1.0    | -      | μF   | MURATA  | GRT188C81E105KE13  |  |
| C_CPP2     | -               | 0.1    | -      | μF   | MURATA  | GRT188R71H104KE13  |  |
| R_RE       | 0.2             | 2.0    | -      | kΩ   | ROHM    | MCR03              |  |
| R_NTC1     | -               | 4.7    | -      | kΩ   | ROHM    | MCR03              |  |
| R_NTC2     | -               | 33     | -      | kΩ   | ROHM    | MCR03              |  |
| R_NTC3     | -               | 10     | -      | kΩ   | MURATA  | NCU18XH103F6SRB    |  |
| R_FLT      | 47              | 100    | 200    | kΩ   | ROHM    | MCR03              |  |
| R_PG       | 47              | 100    | 200    | kΩ   | ROHM    | MCR03              |  |
| R_RST      | 47              | 100    | 200    | kΩ   | ROHM    | MCR03              |  |

(Note 1) Please set in consideration of temperature properties and DC bias properties not to become less than the minimum.  
Please consider it based on enough evaluations with the actual model.

Application Example 1 (when operated by EN control) – continued  
Timing Chart1

Start-up Sequence (when operated by EN control)

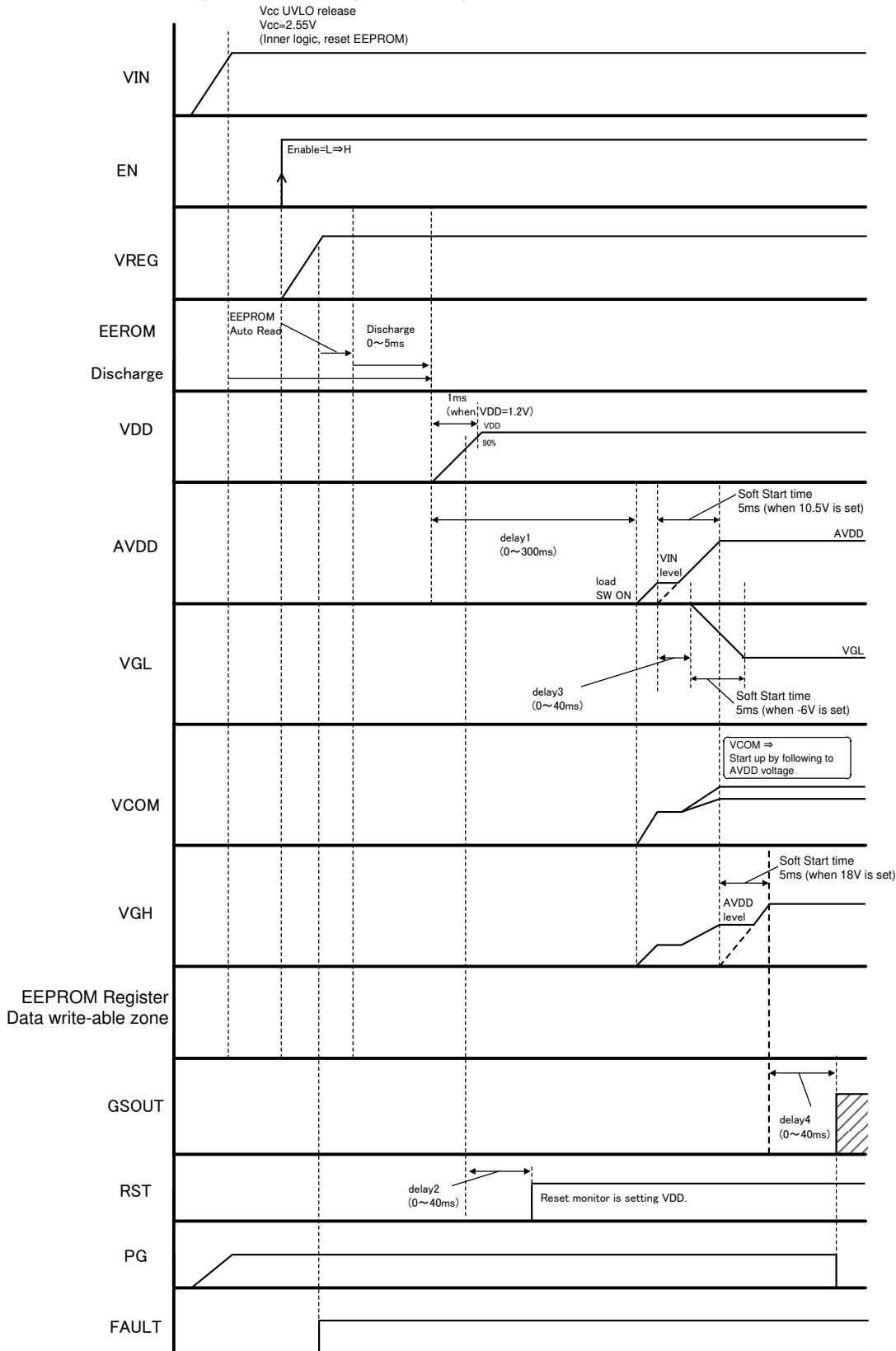


Figure 63. Start-Up Sequence Diagram (when operated by EN control)

Application Example 1 (when operated by EN control) – continued

OFF Sequence (when operated by EN control)

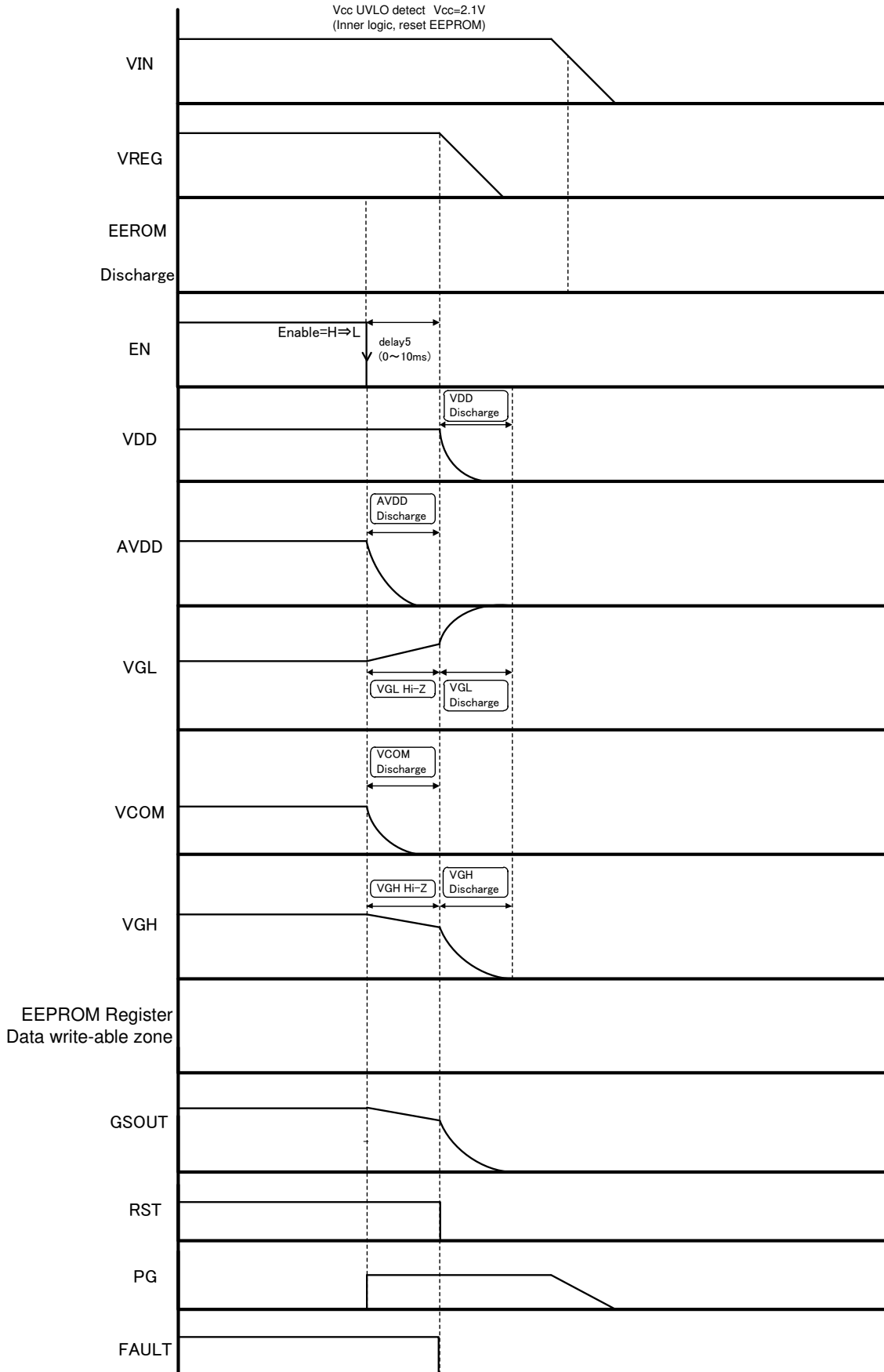


Figure 64. OFF Sequence Block (when operated by EN control)

Application Example 2 (when operated with EN= VCC condition)  
Timing Chart2

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

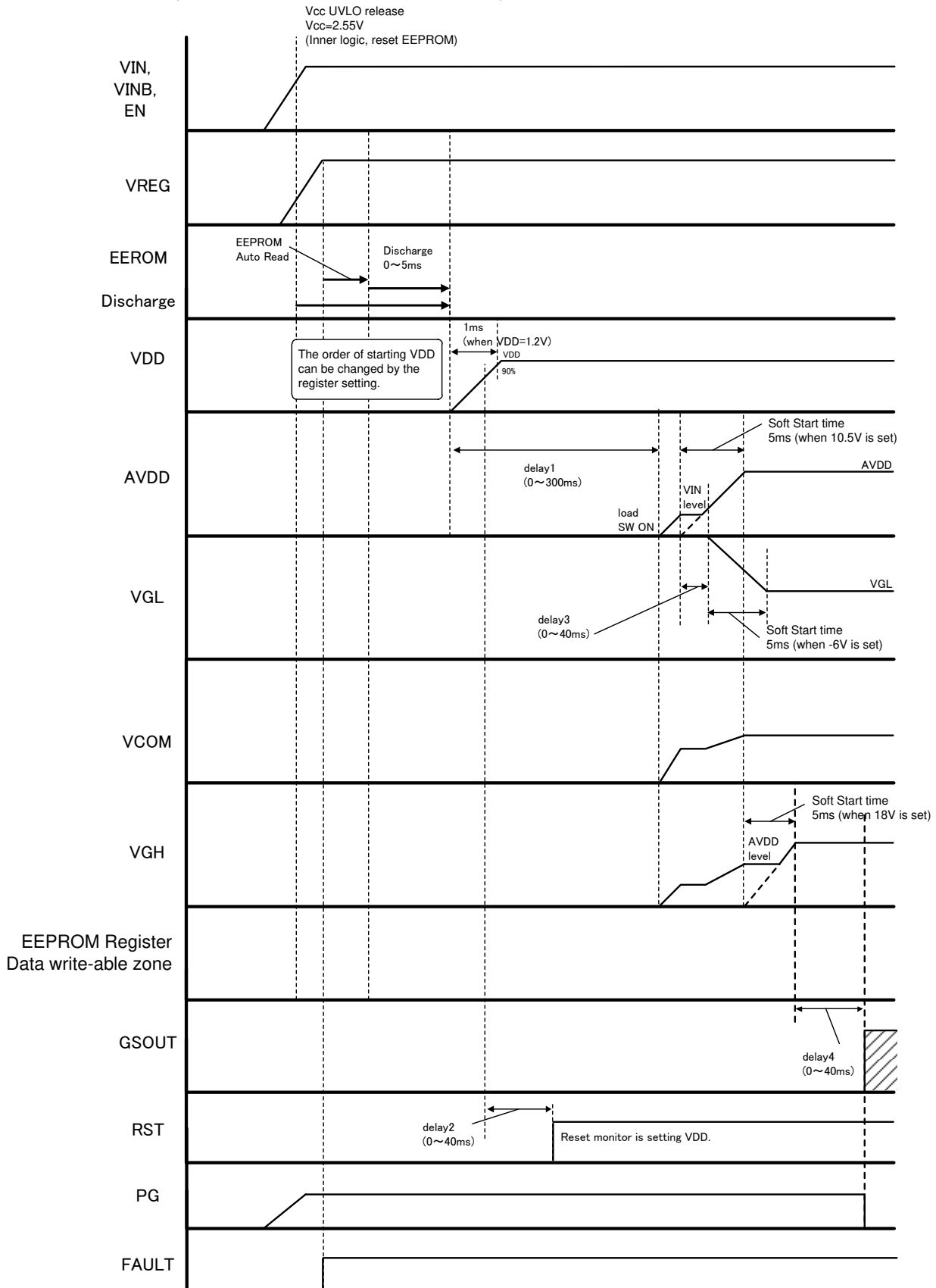


Figure 65. Start-Up Sequence Diagram (when operated with EN= VCC condition)

Timing Chart2 - continued

OFF Sequence (when operated with EN= VCC condition)

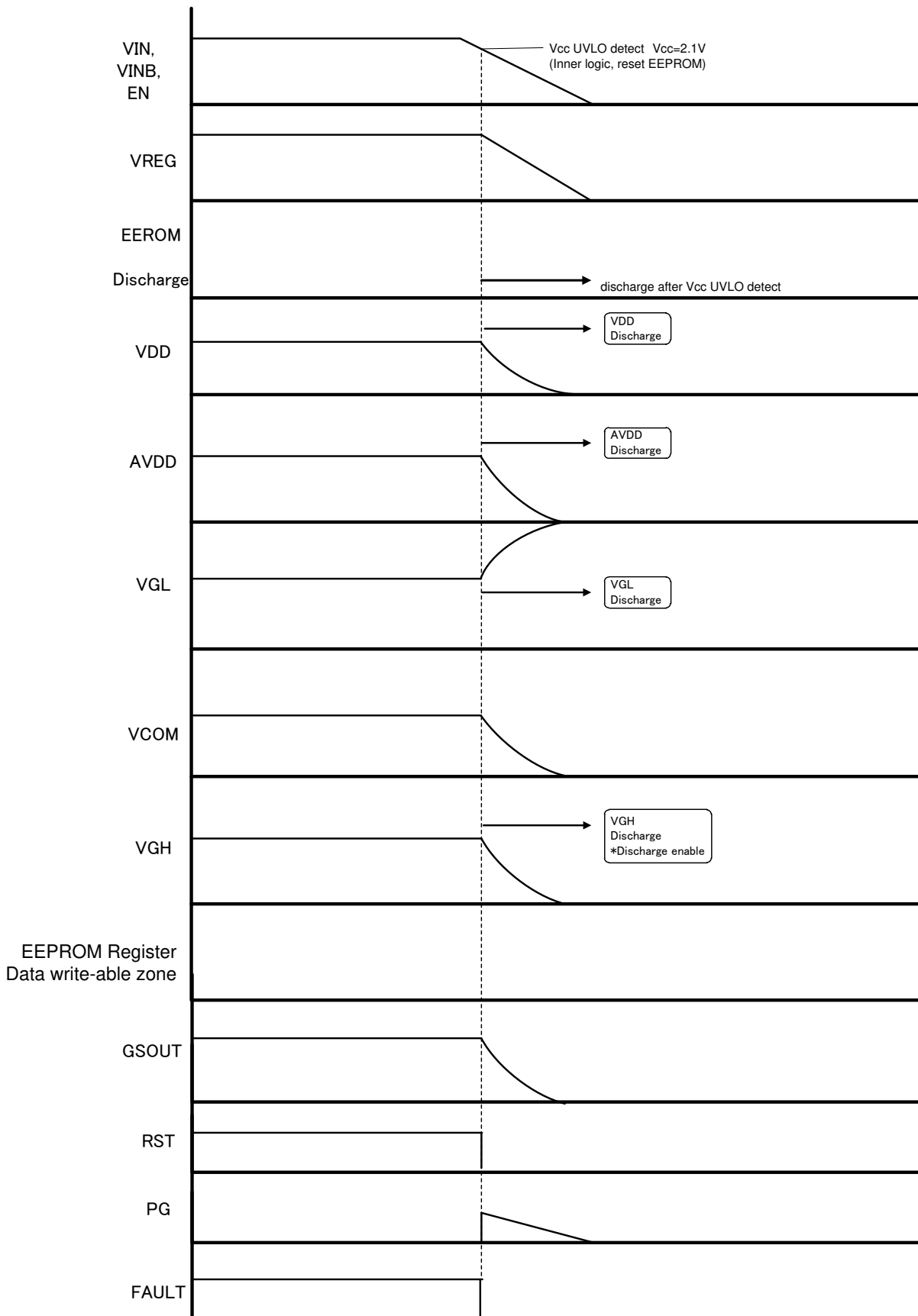


Figure 66. OFF Sequence Diagram (when operated with EN= VCC condition)

Application Example 3 (using LDSW mode)

In case of activating in order of VGL => AVDD => VGH, changing the application contracture to following make is possible. In this case please set Register08h (Function Select) of the EEPROM to "1".

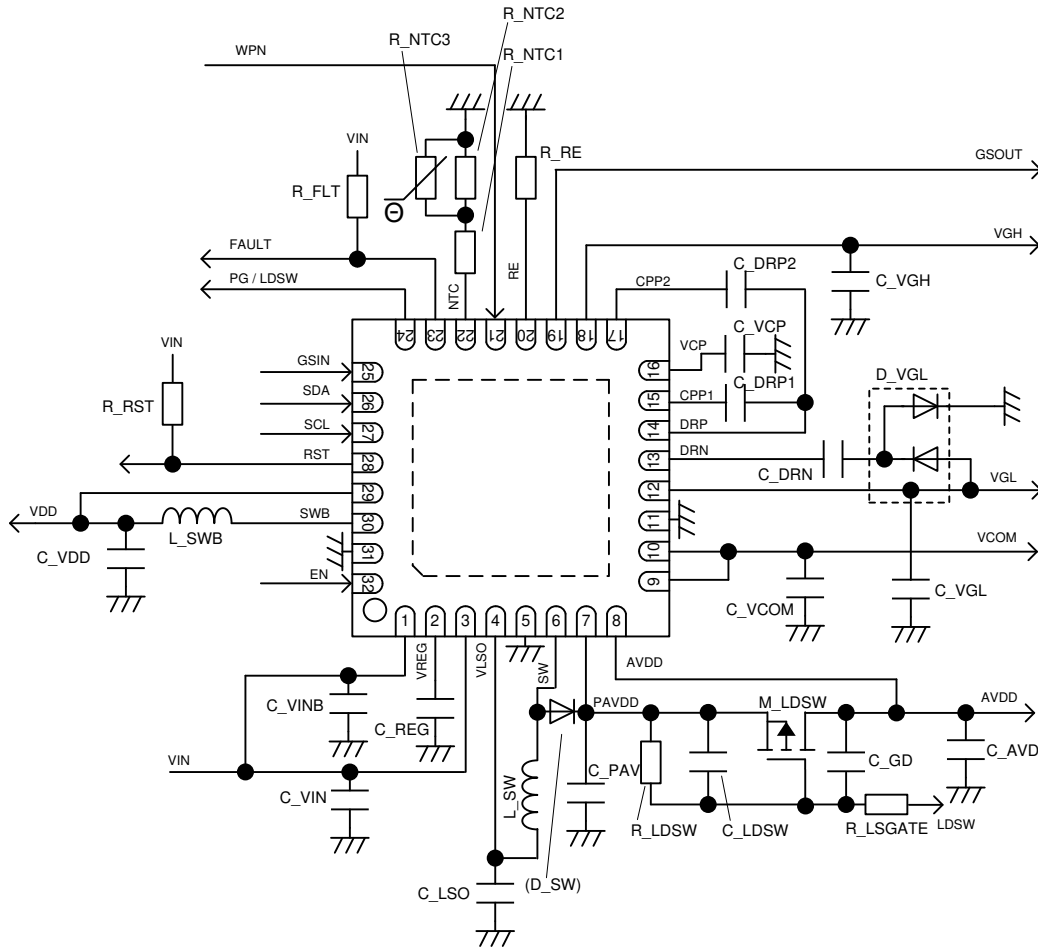


Figure 67. Application Circuit (Function Select = LDSW)

## Application Example 3 (using LDSW mode) - continued

## Application circuit components list

(Unless otherwise specified VIN=3.3V, VDD=2.5V, AVDD=10.5V, VGH=18V, VGL=-6.0V, VCOM=5.25V and Ta=25°C)

| Parts name | Value           |        |        | Unit | Company | Parts Number       | Comment  |
|------------|-----------------|--------|--------|------|---------|--------------------|--|
|            | Min<br>(Note 1) | Typ    | Max    |      |         |                    |  |
| C_VIN      | 10              | 10 x 2 | -      | μF   | MURATA  | GRT21BC81A106KE01  |  |
| C_VINB     | 4.7             | 10     | -      | μF   | MURATA  | GRT21BC81A106KE01  | No need @ VDD LDO mode   |
| C_REG      | 0.047           | 0.1    | 0.47   | μF   | MURATA  | GRT188R71H104KE13  |  |
| C_LSO      | 10              | 10 x 2 | -      | μF   | MURATA  | GRT21BC81A106KE01  |  |
| C_PAVD     | 5.0             | 10 x 2 | 10 x 5 | μF   | MURATA  | GRT31CC81E106KE01  | See p.49 in detail.  |
| C_AVD      | 2.2             | 4.7    | 10     | μF   | MURATA  | GRT31CC81E475KE01  | See p.49 in detail.  |
| L_SW       | -               | 4.7    | -      | μH   | TDK     | LTF5022T-4R7N2R0-H | See p.49 in detail.  |
| D_SW       | -               | -      | -      | -    | ROHM    | (RB060M-30DD)      | Please insert D_SW when improving the efficiency is necessary. |
| M_LDSW     | -               | -      | -      | -    | ROHM    | RTR030P02FHA       |  |
| R_LDSW     | -               | 100    | -      | kΩ   | ROHM    | MCR03              |  |
| C_LDSW     | -               | 0.47   | -      | μF   | MURATA  | GRT21BR71H474KE01  |  |
| C_GD       | -               | 33     | -      | nF   | MURATA  | GRT155R71H333KE01  |  |
| R_LSGATE   | -               | 100    | -      | kΩ   | ROHM    | MCR03              |  |
| C_VDD      | 10              | 10 x 2 | 47     | μF   | MURATA  | GRT21BC81A106KE01  |  |
| L_SWB      | -               | 4.7    | -      | μH   | TDK     | LTF5022T-4R7N2R0-H |  |
| C_VCOM     | -               | -      | -      | μF   | MURATA  | -                  |  |
| C_VGL      | 0.47            | 1.0    | 4.7    | μF   | MURATA  | GRT21BC81E105KE13  |  |
| C_DRN      | -               | 0.1    | -      | μF   | MURATA  | GRT188R71H104KE13  |  |
| D_VGL      | -               | -      | -      | -    | ROHM    | RB558WFH           |  |
| C_VGH      | 0.47            | 2.2    | 4.7    | μF   | MURATA  | GRT21BC8YA225KE13  |  |
| C_CPP1     | -               | 0.1    | -      | μF   | MURATA  | GRT188R71H104KE13  |  |
| C_VCP      | -               | 1.0    | -      | μF   | MURATA  | GRT188C81E105KE13  |  |
| C_CPP2     | -               | 0.1    | -      | μF   | MURATA  | GRT188R71H104KE13  |  |
| R_RE       | 0.2             | 2.0    | -      | kΩ   | ROHM    | MCR03              |  |
| R_NTC1     | -               | 4.7    | -      | kΩ   | ROHM    | MCR03              |  |
| R_NTC2     | -               | 33     | -      | kΩ   | ROHM    | MCR03              |  |
| R_NTC3     | -               | 10     | -      | kΩ   | MURATA  | NCU18XH103F6SRB    |  |
| R_FLT      | 47              | 100    | 200    | kΩ   | ROHM    | MCR03              |  |
| R_RST      | 47              | 100    | 200    | kΩ   | ROHM    | MCR03              |  |

(Note 1) Please set in consideration of temperature properties and DC bias properties not to become less than the minimum.  
Please consider it based on enough evaluations with the actual model.



Timing Chart3

Start-up Sequence (when operated with LDSW function)

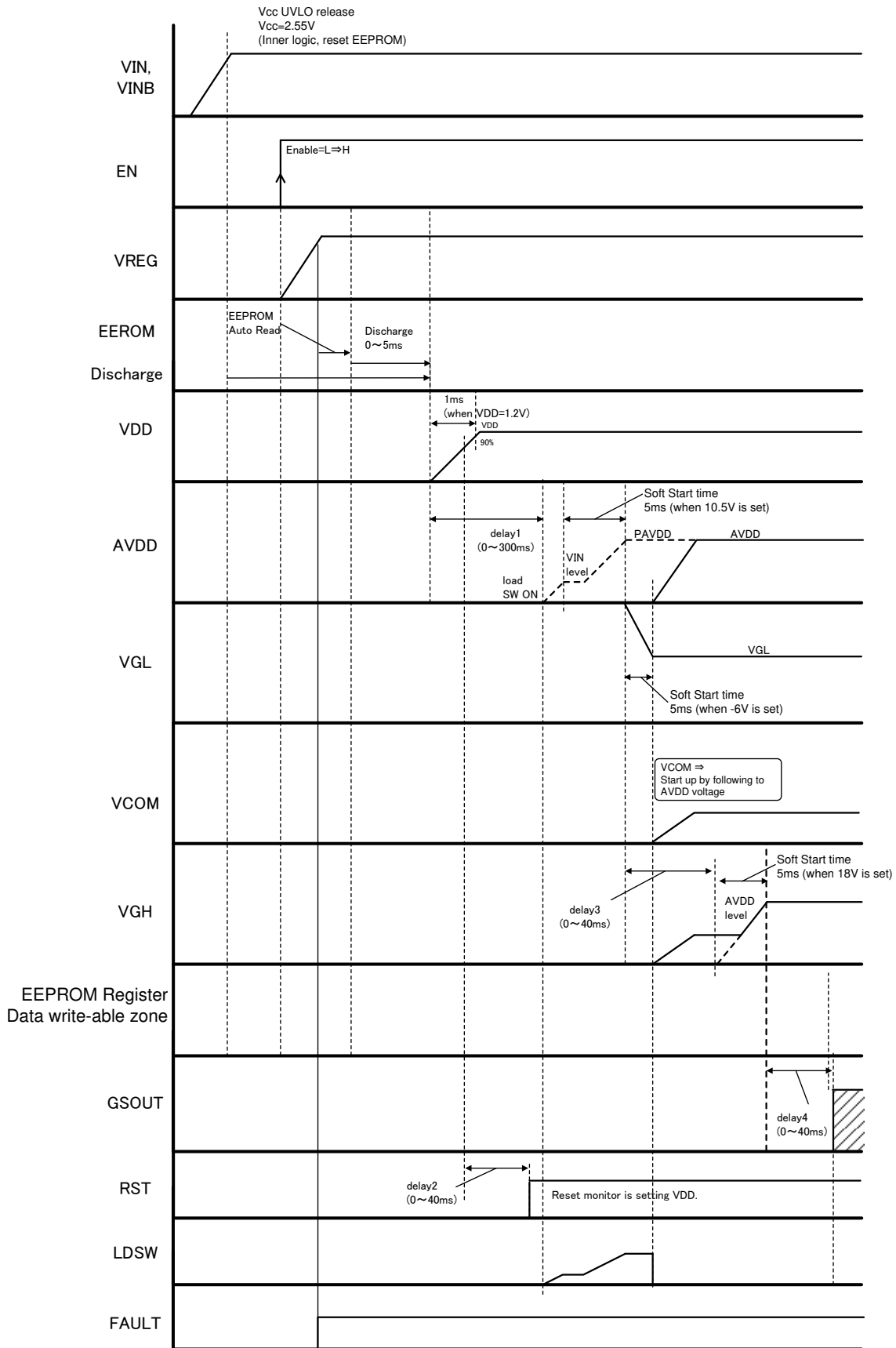


Figure 68. Start-Up Sequence Diagram (when operated with LDSW Function)

Timing Chart3 - continued

OFF Sequence (when operated with LDSW function)

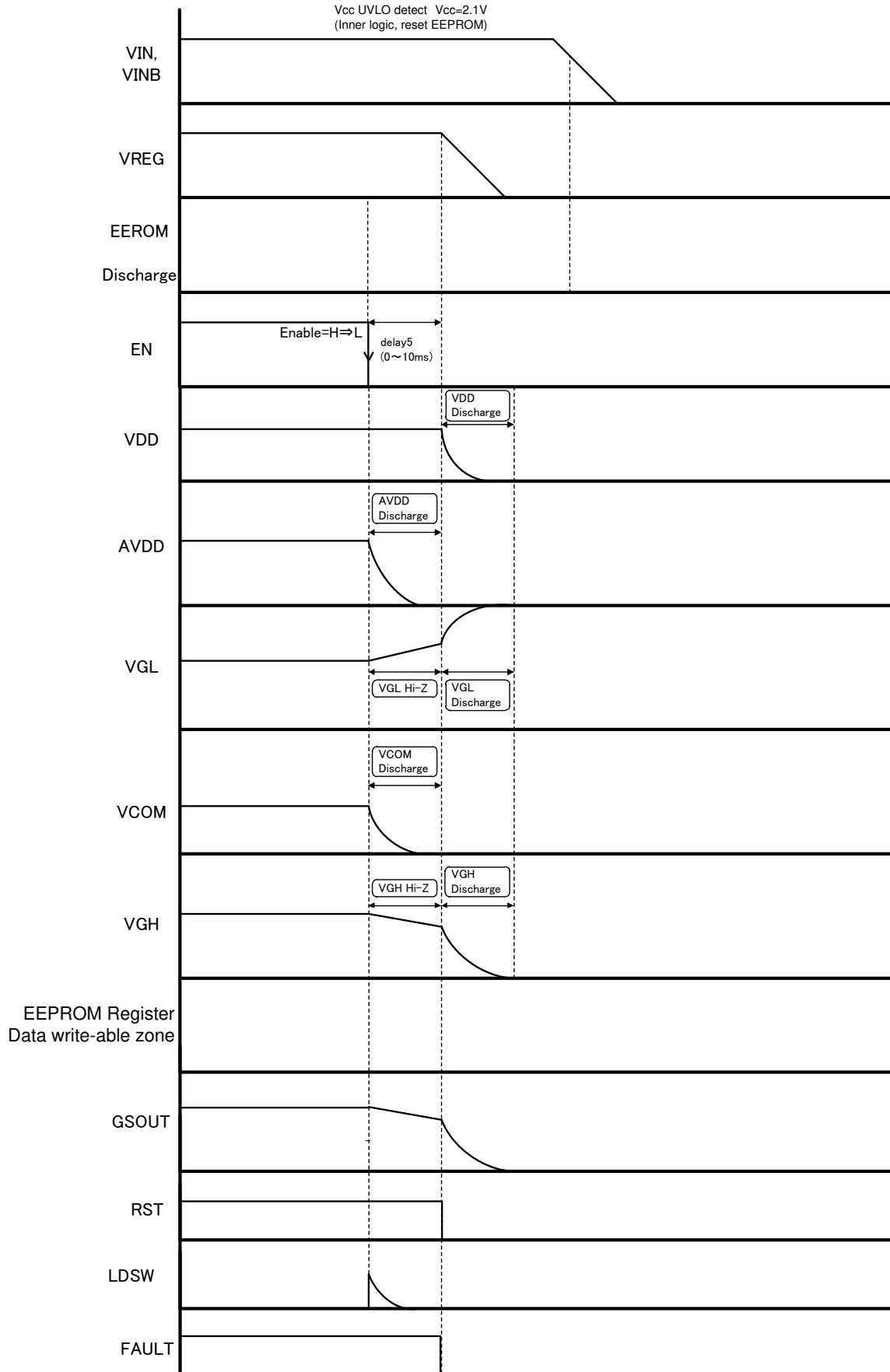


Figure 69. OFF Sequence Diagram (when operated with LDSW Function)

Serial communication

This IC has two device-address-differential EEPROM installed and data is send or received to/from EEPROM using 2-line serial interface (SCL, SDA). Communication format for data sending or receiving to/from each EEPROM is shown below.

EEPROM I2C Format for DVR (VCOM calibrator)

|                 |       |                |   |   |   |   |   |   |     |     |      |    |    |    |    |    |    |     |      |
|-----------------|-------|----------------|---|---|---|---|---|---|-----|-----|------|----|----|----|----|----|----|-----|------|
| Write operation | Start | Device address |   |   |   |   |   |   | R/W | ACK | DATA |    |    |    |    |    |    | ACK | STOP |
|                 |       | 1              | 0 | 0 | 1 | 1 | 1 | 1 | 0   | 0   | D6   | D5 | D4 | D3 | D2 | D1 | D0 | P   |      |
| Read operation  | Start | Device address |   |   |   |   |   |   | R/W | ACK | DATA |    |    |    |    |    |    | ACK | STOP |
|                 |       | 1              | 0 | 0 | 1 | 1 | 1 | 1 | 1   | 0   | D6   | D5 | D4 | D3 | D2 | D1 | D0 | X   |      |

When Device Address = 1001111(R/W) is selected, Data is Read or Write EEPROM for DVR(VCOM calibrator).

During Write mode

- When P=1, the sending data is written only to Register.
- When WPN=Low and P=0, the sending data is written only to Register.
- When WPN=High and P=0, the sending data is written both to Register and EEPROM.

During Read mode

The last bit of received data is "Don't care".

"D6" is ± select bit: 0 = "+", 1="-" from VCOM(HOT) value.

[D5:D0] are voltage band from VCOM(HOT).

The voltage band is calculated; 10mV x [D5:D0],

For example,

[D6:D0,P] = 82h(D6=1, [D5:D0]=1'd, P=0) ... VCOM = VCOM(HOT) – 1 x 10mV;

[D6:D0,P] = 7Eh(D6=0, [D5:D0]=63'd, P=0) ... VCOM = VCOM(HOT) + 63 x 10mV;

Sequence of DVR side EEPROM during Read/Write mode is shown in below chart.

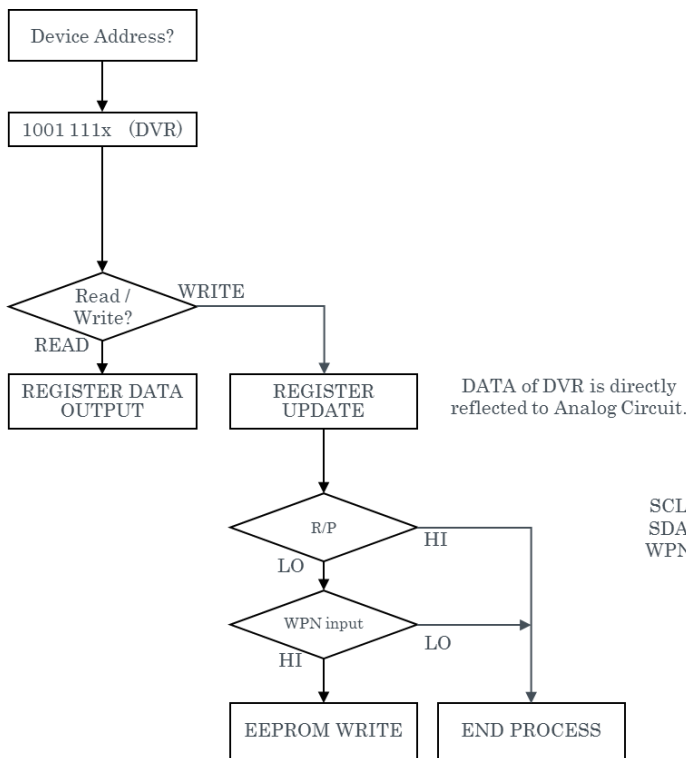


Figure 70

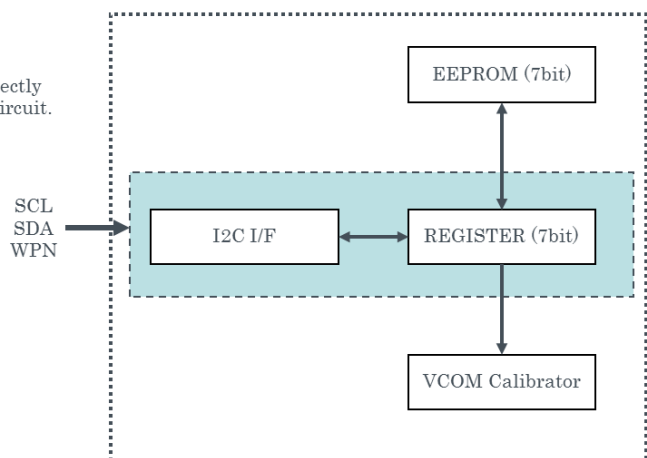


Figure 71

Serial communication - continued

EEPROM I2C Format for Power Management IC (PMIC)

|                 |       |                |   |   |   |   |   |   |   |     |     |                  |                     |   |  |  |  |  |  |     |                |                |   |  |  |  |  |  |     |      |              |   |  |  |  |  |  |  |     |      |
|-----------------|-------|----------------|---|---|---|---|---|---|---|-----|-----|------------------|---------------------|---|--|--|--|--|--|-----|----------------|----------------|---|--|--|--|--|--|-----|------|--------------|---|--|--|--|--|--|--|-----|------|
| Write operation | Start | Device address |   |   |   |   |   |   |   | R/W | ACK | Register Address |                     |   |  |  |  |  |  | ACK | N-bytes Data   |                |   |  |  |  |  |  | ACK | Stop |              |   |  |  |  |  |  |  |     |      |
|                 |       | 1              | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0   | 0   | 0                | 00h ~ 0Dh, 10h, 11h | 0 |  |  |  |  |  |     |                |                | 0 |  |  |  |  |  |     |      |              |   |  |  |  |  |  |  |     |      |
| Read operation  | Start | Device address |   |   |   |   |   |   |   | R/W | ACK | Register Address |                     |   |  |  |  |  |  | ACK | Repeated Start | Device Address |   |  |  |  |  |  |     | ACK  | N-bytes Data |   |  |  |  |  |  |  | ACK | Stop |
|                 |       | 1              | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0   | 0   | 0                | 00h ~ 0Dh, 10h, 11h | 0 |  |  |  |  |  |     |                |                | 1 |  |  |  |  |  |     |      |              | 1 |  |  |  |  |  |  |     |      |

Device Address of BM81810MUV-M is 1000 000x.  
Multi write is possible until Register 00h to 0Dh.

|   | EN   | WPN  | Start-up( 0Ch[7] ) | PMIC ( 00h to 0Dh) | Output Function |
|---|------|------|--------------------|--------------------|-----------------|
| 1 | Low  | Low  | -                  | -                  | Shutdown        |
| 2 | High | Low  | -                  | Register           | Active          |
| 3 | High | High | 0*                 | Register & EEPROM  | Shutdown        |
| 4 | High | High | 1                  | Register & EEPROM  | Active          |

\* In the mass production shipment process, please write Start-up ( 0Ch[7] ) to "1" in EEPROM.

The following are the settings if you want to send the Data by I2C.

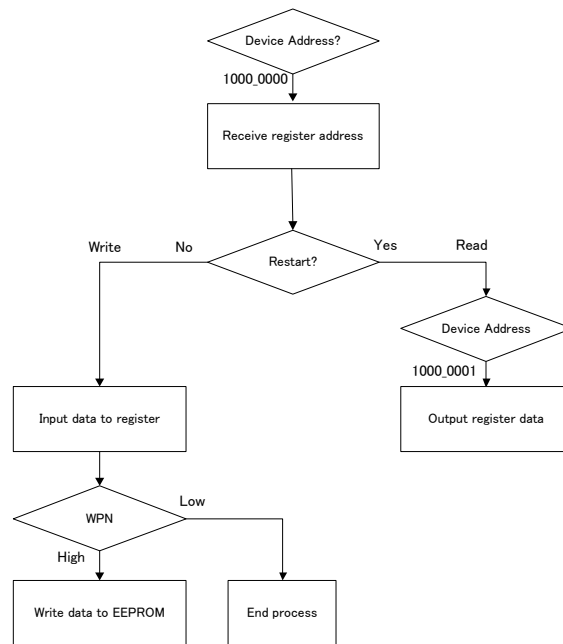


Figure 72

WPN Timing

WPN is normally fixed as Low.

In case of writing to EEPROM, WPN is set to High, and the timing will be as below.

Because the maximum of the auto-read time from EEPROM is 5ms, please between EN signal and I2C input than 5ms.

Also, because the maximum of writing time to EEPROM is 50ms, please between I2C STOP signal and EN falling signal than 50ms.



Figure 73

I2C Timing Diagram

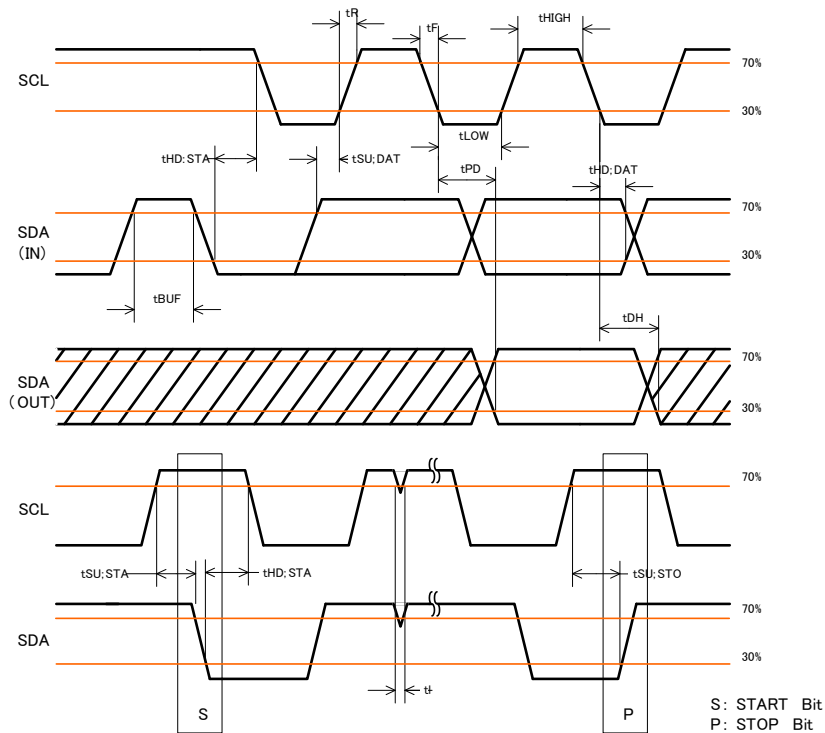


Figure 74. I2C Timing Diagram

Timing standard values

| Parameter                  | Symbol  | NORMAL MODE |     |     | FAST MODE |     |     | Unit |
|----------------------------|---------|-------------|-----|-----|-----------|-----|-----|------|
|                            |         | Min         | Typ | Max | Min       | Typ | Max |      |
| SCL frequency              | fSCL    | -           | -   | 100 | -         | -   | 400 | kHz  |
| SCL high time              | tHIGH   | 4.0         | -   | -   | 0.6       | -   | -   | μs   |
| SCL low time               | tLOW    | 4.7         | -   | -   | 1.2       | -   | -   | μs   |
| Rise Time                  | tR      | -           | -   | 1.0 | -         | -   | 0.3 | μs   |
| Fall Time                  | tF      | -           | -   | 0.3 | -         | -   | 0.3 | μs   |
| Start condition hold time  | tHD;STA | 4.0         | -   | -   | 0.6       | -   | -   | μs   |
| Start condition setup time | tSU;STA | 4.7         | -   | -   | 0.6       | -   | -   | μs   |
| SDA hold time              | tHD;DAT | 0           | -   | -   | 0         | -   | -   | ns   |
| SDA setup time             | tSU;DAT | 200         | -   | -   | 100       | -   | -   | ns   |
| Acknowledge delay time     | tPD     | -           | -   | 0.9 | -         | -   | 0.9 | μs   |
| Acknowledge hold time      | tDH     | -           | 0.1 | -   | -         | 0.1 | -   | μs   |
| Stop condition setup time  | tSU;STO | 4.0         | -   | -   | 0.6       | -   | -   | μs   |
| Bus release time           | tBUF    | 4.7         | -   | -   | 1.2       | -   | -   | μs   |
| Noise spike width          | TI      | -           | 0.1 | -   | -         | 0.1 | -   | μs   |

**Automatic EEPROM Read Function at Start-up**

Upon BM81810MUV-M start-up, a reset signal is generated and each register is initialized. After VREG activation is finished, data which is stored in the EEPROM is copied to the registers. The automatic EEPROM read function at start-up is further explained by the flow chart below.

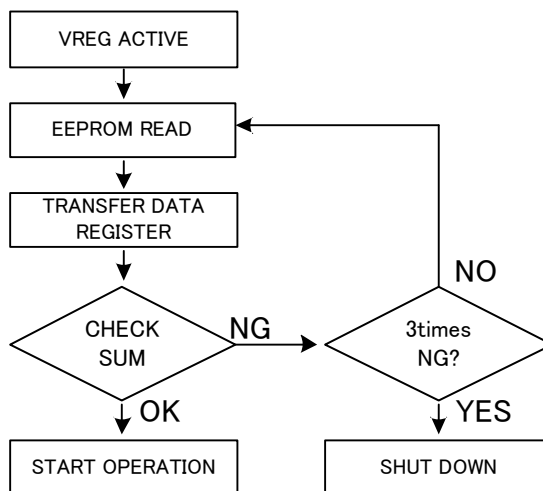


Figure 75. Automatic EEPROM Read Function at Start-up

EEPROM Parameter Setting

| ■EEPROM / Main Register Map ( device address : 1000000x ) |      |   |  |   |
|---|------|---|--|---|
| Device Address: 1000000x (PMIC)                           |      |   |  |   |
| Register Address  | Bits | Function  | Resolution   | Comments  |
| 00h   | 8    | AVDD Output voltage                               | 0.1V [5.0V to 17.0V]                               | AVDD Output voltage setting                                       |
| 01h   | 8    | VGH(HOT) Output voltage                           | 0.2V [8.0V to 35.0V]                               | VGH(HOT) Output voltage setting                                   |
| 02h   | 8    | Δ VGH(COLD) Voltage [6:0]<br>VGH NTC Enalbe [7]   | 0.2V [VGH(HOT) + 15V]<br>0:Disable, 1:Enable       |   |
| 03h   | 8    | VGL Output voltage                                | 0.1V [-14.0V to -4.0V]                             | VGL Output voltage setting  |
| 04h   | 8    | VCOM(HOT) Output voltage                          | 40mV [0.5xAVDD ±4.0V]                              | VCOM(HOT) Output voltage setting                                  |
| 05h   | 8    | Δ VCOM(COLD) Voltage [6:0]<br>VCOM NTC Enalbe [7] | 10mV [VCOM(HOT) - 0.63V]<br>0:Disable, 1:Enable    |   |
| 06h   | 8    | VDD Output voltage [5:0]                          | 0.05V [0.9V to 3.4V]                               | VDD Output voltage setting  |
|   |      | VDD mode select [6]                               | 0 : DC/DC, 1 : LDO                                 | Select VDD operation mode DC/DC or LDO                            |
|   |      | VDD Phase [7]                                     | See P.56 page.                                     | select VDD Phase  |
| 07h   | 8    | Reset Voltage [4:0]                               | 0.1V [0.6V to 3.3V]                                | Reset voltage setting   |
|   |      | Reset monitor select [5]                          | 0:VDD, 1:VIN                                       | Select monitor pin of reset function                              |
|   |      | GPM input delay [7:6]                             | 00: 0.1usec, 01: 0.5usec, 10: 1.0usec, 11: 1.5usec | GPM input propagation delay time setting                          |
| 08h   | 8    | Discharge time [2:0]                              | 1msec [0 to 5msec]                                 | Pre-discharge time setting  |
|   |      | Delay1 time [6:3]                                 | [0 to 300msec]                                     | Load switch of AVDD start-up delay time setting                   |
|   |      | Function Select [7]                               | 0: PG, 1: LDSW                                     | 24pin function select   |
| 09h   | 8    | Delay2 time [2:0]                                 | 5msec [0 to 30msec, 40msec]                        | Reset start delay time setting                                    |
|   |      | DoubleReg [3]                                     | 0: Disable, 1: Enable                              | Double Register Function  |
|   |      | Delay3 time [6:4]                                 | 5msec [0 to 30msec, 40msec]                        | VGL or VGH start-up delay time setting                            |
|   |      | DataRef [7]                                       | 0: Disable, 1: Enable                              | Data Refresh Function   |
| 0Ah   | 8    | Delay4 time [2:0]                                 | 5msec [0 to 30msec, 40msec]                        | GPM start delay time setting                                      |
|   |      | AR_Time [3]                                       | 0: 0.5sec, 1: 1.0sec                               | Data Refresh Time   |
|   |      | Delay5 time [6:4]                                 | 2msec [0 to 10msec]                                | VDD stop delay time setting                                       |
|   |      | VGH Discharge enable [7]                          | 0: Enable, 1: Disable                              | VGH Discharge function enable                                     |
| 0Bh   | 8    | AVDD Coil[1:0]                                    | See p.49 page.                                     | select AVDD Coil inductance                                       |
|   |      | AVDD SW Slew Rate [3:2]                           | See p.48 page.                                     | 4step slew rate setting<br>(11:fast → 00:slow)                    |
|   |      | AVDD SS time [5:4]                                | 5msec [5msec to 20msec]                            | AVDD softstart time setting                                       |
|   |      | AVDD OCP Select [6]                               | 0: 2A, 1: 1A                                       | AVDD OCP min value select   |
|   |      | AVDD COMP [7]                                     | See p.49 page.                                     | AVDD phase compensation setting                                   |
| 0Ch   | 8    | AVDD Frequecy [1:0]                               | 00:2.1MHz, 01:1.05MHz, 10:525KHz, 11:525KHz        | Select AVDD switching frequency                                   |
|   |      | VDD Frequecy [3:2]                                | 00:2.1MHz, 01:1.05MHz, 10:525KHz, 11:525KHz        | Select VDD switching frequency                                    |
|   |      | VGH / VGL Frequecy [5:4]                          | AVDD Frequecy<br>( 00:x1, 01:--, 10:--, 11:-- )    | Select VGH and VGL switching frequency. <b>Choose only "00"</b> . |
|   |      | VGH mode select [6]                               | 0: x3 mode, 1: x2 or x4 mode                       | Select VGH charge pump mode                                       |
|   |      | start-up bit [7]                                  | 0:Disable, 1:Enable                                |   |

| Device Address: 1001111x (VCOM) |      |                 |                             |                 |
|---------------------------------|------|-----------------|-----------------------------|-----------------|
| Register Address                | Bits | Function        | Resolution                  | Comments        |
| -                               | 7    | VCOM Calibrator | +/- 0.01V [ VCOM +/- 0.63V] | VCOM Calibrator |

When Start-up bit(REG0Ch[7]) is "1", below Register cannot be modified.

- VGH NTC Enable REG02h[7]
- VCOM NTC Enable REG05h[7]
- VDD mode select REG06h[6]
- Function select REG08h[7]
- VGH mode select REG0Ch[6]

To change those Register setting, start-up bit(REG0Ch[7]) should be in "0".  
After changing the register value, set the Start-up bit(REG0Ch[7]) to "1" again to start up with the changed setting.

Register Map

Device Address : 1000000x (PMIC)

| Register Address | D7                      | D6                         | D5                   | D4            | D3                    | D2       | D1               | D0              | Default |
|------------------|-------------------------|----------------------------|----------------------|---------------|-----------------------|----------|------------------|-----------------|---------|
| 00h              | AVDD Output Voltage     |                            |                      |               |                       |          |                  |                 | 68h     |
| 01h              | VGH HOT Output Voltage  |                            |                      |               |                       |          |                  |                 | 59h     |
| 02h              | VGH NTC Enable          | $\Delta$ VGH COLD Voltage  |                      |               |                       |          |                  |                 | 83h     |
| 03h              | VGL Output Voltage      |                            |                      |               |                       |          |                  |                 | 3Bh     |
| 04h              | VCOM HOT Output Voltage |                            |                      |               |                       |          |                  |                 | 80h     |
| 05h              | VCOM NTC Enable         | $\Delta$ VCOM COLD Voltage |                      |               |                       |          |                  |                 | 99h     |
| 06h              | VDD Phase Select        | VDD MODE                   | VDD Output Voltage   |               |                       |          |                  |                 | 20h     |
| 07h              | GPM Input Delay         |                            | Reset Monitor Select | Reset Voltage |                       |          |                  |                 | 04h     |
| 08h              | Function Select         | Delay1 time                |                      |               | Discharge time        |          |                  |                 | 09h     |
| 09h              | Data Refresh            | Delay3 time                |                      | DoubleReg     | Delay2 time           |          |                  |                 | 13h     |
| 0Ah              | VGH Discharge Enable    | Delay5 time                |                      | AR_Time       | Delay4 time           |          |                  |                 | 87h     |
| 0Bh              | AVDD COMP               | AVDD OCP Select            | AVDD SS Time         |               | AVDD SW Slew Rate     |          | AVDD Coil Select |                 | 3Ch     |
| 0Ch              | Start-up Bit            | VGH mode select            | VGH/VGL Frequency    |               | VDD Frequency         |          | AVDD Frequency   |                 | 05h     |
| 0Dh              | Check Sum               |                            |                      |               |                       |          |                  |                 | 60h     |
| 10h              | AVDD UVP                | VDD UVP                    | VGH UVP              | VGL UVP       | Double Register Error | AVDD OCP | TSD              | Check sum Error | 00h     |

Device Address : 1001111x (VCOM)

| Register Address | D6                       | D5 | D4 | D3 | D2 | D1 | D0 | P | Default |
|------------------|--------------------------|----|----|----|----|----|----|---|---------|
| -                | VCOM Calibration Voltage |    |    |    |    |    |    | P | 80h     |



Register Map - continued
Command Table

Table with 15 columns: DATA (HEX), 00h, 01h, 02h, 03h, 04h, 05h, 06h, 07h, 08h. Rows list register addresses and their corresponding configuration values and functions.

Command Table - continued

Table with columns: DATA (HEX), AVDD Output Voltage [7:0], VGH HOT Output Voltage [7:0], VGH NTC Enable [7], VGH COLD Voltage [6:0], VGL Output Voltage [7:0], VCOM HOT Output Voltage [7:0], VCOM COLD Voltage [6:0], VDD Phase [7], VDD MODE [6], VDD Output Voltage [5:0], GPM Input Delay [7:6], Reset Monitor Select [5], Reset Voltage [4:0], Function Select [7], Delay 1 time [6:3], Discharge time [2:0]. Rows include commands 80h to FFh with various voltage and timing specifications.

Command Table - continued

| DATA (HEX)  | Register Address  |               |                   |                          |                   |             |                   |                |                     |                    |                         |                |                |                         | Start-up Bit [7]    | VGH mode select [6] | 0Ch                     |                     | Check Sum [7:0] |          |         |        |         |
|-------------|-------------------|---------------|-------------------|--------------------------|-------------------|-------------|-------------------|----------------|---------------------|--------------------|-------------------------|----------------|----------------|-------------------------|---------------------|---------------------|-------------------------|---------------------|-----------------|----------|---------|--------|---------|
|             | 09h               |               |                   |                          | 0Ah               |             |                   |                | 0Bh                 |                    |                         |                |                |                         |                     |                     | VGH/VGL Frequency [5:4] | VDD Frequency [3:2] |                 |          |         |        |         |
| DataRef [7] | Delay3 time [6:4] | DoubleReg [3] | Delay2 time [2:0] | VGH Discharge Enable [7] | Delay5 time [6:4] | AR_Time [3] | Delay4 time [2:0] | AVDD COMP [7]  | AVDD OCP Select [6] | AVDD SS time [5:4] | AVDD SW Slew Rate [3:2] | AVDD COL [1:0] | AVDD COL [1:0] | VGH/VGL Frequency [5:4] | VDD Frequency [3:2] |                     |                         |                     |                 |          |         |        |         |
| 00h         | Disable           | Disable       | 0 msec            | Enable                   | Enable            | 0.5 sec     | 0 msec            | AV_COM P_Sel 1 | 2.0 A               | 5 msec             | Slow2                   | AVC Set1       | 2.1MHz         | x3 mode                 | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 01h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 02h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 03h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set4       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 04h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set1       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 05h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 06h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 07h         |                   |               | AVC Set4          |                          |                   | 1.05MHz     | 1.05MHz           |                |                     |                    |                         |                |                |                         |                     |                     |                         |                     |                 |          |         |        |         |
| 08h         |                   |               | Fast1             |                          |                   | 1.0 sec     | 5 msec            |                |                     |                    | 2 msec                  | 1.0 sec        | 2 msec         |                         | 10 msec             | 10 msec             | 10 msec                 | 10 msec             | Fast1           | AVC Set1 | 2.1MHz  | 525KHz | 2.1MHz  |
| 09h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     |                         |                     |                 | AVC Set2 | 1.05MHz |        | 1.05MHz |
| 0Ah         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     |                         |                     |                 | AVC Set3 | 525KHz  |        | 525KHz  |
| 0Bh         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     |                         |                     |                 | AVC Set4 | 2.1MHz  |        | 2.1MHz  |
| 0Ch         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     |                         |                     |                 | AVC Set1 | 1.05MHz |        | 1.05MHz |
| 0Dh         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     |                         |                     |                 | AVC Set2 | 525KHz  |        | 525KHz  |
| 0Eh         |                   | AVC Set3      |                   |                          | 2.1MHz            |             |                   |                |                     | 2.1MHz             |                         |                |                |                         |                     |                     |                         |                     |                 |          |         |        |         |
| 0Fh         |                   | AVC Set4      | 1.05MHz           |                          | 1.05MHz           |             |                   |                |                     |                    |                         |                |                |                         |                     |                     |                         |                     |                 |          |         |        |         |
| 10h         |                   | Slow2         | 0.5 sec           |                          | 10 msec           | 4 msec      | 0.5 sec           |                |                     | 4 msec             | 4 msec                  | 15 msec        | 15 msec        |                         | 15 msec             | Slow2               | AVC Set1                | 2.1MHz              | 525KHz          | 2.1MHz   |         |        |         |
| 11h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     | AVC Set2                | 1.05MHz             |                 | 1.05MHz  |         |        |         |
| 12h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     | AVC Set3                | 525KHz              |                 | 525KHz   |         |        |         |
| 13h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     | AVC Set4                | 2.1MHz              |                 | 2.1MHz   |         |        |         |
| 14h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     | AVC Set1                | 1.05MHz             |                 | 1.05MHz  |         |        |         |
| 15h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     | AVC Set2                | 525KHz              |                 | 525KHz   |         |        |         |
| 16h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     | AVC Set3                | 2.1MHz              |                 | 2.1MHz   |         |        |         |
| 17h         |                   | AVC Set4      | 1.05MHz           |                          | 1.05MHz           |             |                   |                |                     |                    |                         |                |                |                         |                     |                     |                         |                     |                 |          |         |        |         |
| 18h         |                   | Slow1         | 1.0 sec           |                          | 20 msec           | 6 msec      | 1.0 sec           |                |                     | 6 msec             | 6 msec                  | 20 msec        | 20 msec        |                         | 20 msec             | Slow1               | AVC Set1                | 2.1MHz              | 525KHz          | 2.1MHz   |         |        |         |
| 19h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     | AVC Set2                | 1.05MHz             |                 | 1.05MHz  |         |        |         |
| 1Ah         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     | AVC Set3                | 525KHz              |                 | 525KHz   |         |        |         |
| 1Bh         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     | AVC Set4                | 2.1MHz              |                 | 2.1MHz   |         |        |         |
| 1Ch         | AVC Set1          |               |                   | 1.05MHz                  |                   |             |                   | 1.05MHz        |                     |                    |                         |                |                |                         |                     |                     |                         |                     |                 |          |         |        |         |
| 1Dh         | AVC Set2          |               |                   | 525KHz                   |                   |             |                   | 525KHz         |                     |                    |                         |                |                |                         |                     |                     |                         |                     |                 |          |         |        |         |
| 1Eh         | AVC Set3          |               |                   | 2.1MHz                   |                   |             |                   | 2.1MHz         |                     |                    |                         |                |                |                         |                     |                     |                         |                     |                 |          |         |        |         |
| 1Fh         | AVC Set4          | 1.05MHz       | 1.05MHz           |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     |                         |                     |                 |          |         |        |         |
| 20h         | Fast1             | 1.0 sec       | 30 msec           | 8 msec                   | 1.0 sec           | 8 msec      | 8 msec            | 30 msec        | 30 msec             | 30 msec            | Fast1                   | AVC Set1       | 2.1MHz         | 525KHz                  | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 21h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 22h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 23h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set4       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 24h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set1       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 25h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 26h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 27h         | AVC Set4          | 1.05MHz       | 1.05MHz           |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     |                         |                     |                 |          |         |        |         |
| 28h         | Fast2             | 1.0 sec       | 40 msec           | 10 msec                  | 0.5 sec           | 10 msec     | 10 msec           | 10 msec        | 10 msec             | 10 msec            | Fast2                   | AVC Set1       | 2.1MHz         | 525KHz                  | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 29h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 2Ah         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 2Bh         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set4       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 2Ch         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set1       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 2Dh         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 2Eh         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 2Fh         | AVC Set4          | 1.05MHz       | 1.05MHz           |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     |                         |                     |                 |          |         |        |         |
| 30h         | Slow2             | 0.5 sec       | 0 msec            | 15 msec                  | 0.5 sec           | 15 msec     | 15 msec           | 15 msec        | 15 msec             | 15 msec            | Slow2                   | AVC Set1       | 2.1MHz         | 525KHz                  | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 31h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 32h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 33h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set4       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 34h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set1       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 35h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 36h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 37h         | AVC Set4          | 1.05MHz       | 1.05MHz           |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     |                         |                     |                 |          |         |        |         |
| 38h         | Slow1             | 1.0 sec       | 10 msec           | 15 msec                  | 1.0 sec           | 15 msec     | 15 msec           | 15 msec        | 15 msec             | 15 msec            | Slow1                   | AVC Set1       | 2.1MHz         | 525KHz                  | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 39h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 3Ah         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 3Bh         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set4       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 3Ch         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set1       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 3Dh         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 3Eh         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 3Fh         | AVC Set4          | 1.05MHz       | 1.05MHz           |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     |                         |                     |                 |          |         |        |         |
| 40h         | Fast1             | 1.0 sec       | 10 msec           | 20 msec                  | 0.5 sec           | 20 msec     | 20 msec           | 20 msec        | 20 msec             | 20 msec            | Fast1                   | AVC Set1       | 2.1MHz         | 525KHz                  | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 41h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 42h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 43h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set4       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 44h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set1       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 45h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 46h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 47h         | AVC Set4          | 1.05MHz       | 1.05MHz           |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     |                         |                     |                 |          |         |        |         |
| 48h         | Fast2             | 1.0 sec       | 20 msec           | 30 msec                  | 0.5 sec           | 30 msec     | 30 msec           | 30 msec        | 30 msec             | 30 msec            | Fast2                   | AVC Set1       | 2.1MHz         | 525KHz                  | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 49h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 4Ah         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 4Bh         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set4       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 4Ch         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set1       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 4Dh         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 4Eh         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 4Fh         | AVC Set4          | 1.05MHz       | 1.05MHz           |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     |                         |                     |                 |          |         |        |         |
| 50h         | Slow2             | 0.5 sec       | 30 msec           | 40 msec                  | 0.5 sec           | 40 msec     | 40 msec           | 40 msec        | 40 msec             | 40 msec            | Slow2                   | AVC Set1       | 2.1MHz         | 525KHz                  | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 51h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 52h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 53h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set4       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 54h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set1       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 55h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 56h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 57h         | AVC Set4          | 1.05MHz       | 1.05MHz           |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     |                         |                     |                 |          |         |        |         |
| 58h         | Slow1             | 1.0 sec       | 40 msec           | 50 msec                  | 0.5 sec           | 50 msec     | 50 msec           | 50 msec        | 50 msec             | 50 msec            | Slow1                   | AVC Set1       | 2.1MHz         | 525KHz                  | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 59h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 5Ah         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 5Bh         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set4       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 5Ch         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set1       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 5Dh         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 5Eh         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 5Fh         | AVC Set4          | 1.05MHz       | 1.05MHz           |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     |                         |                     |                 |          |         |        |         |
| 60h         | Fast1             | 1.0 sec       | 50 msec           | 60 msec                  | 0.5 sec           | 60 msec     | 60 msec           | 60 msec        | 60 msec             | 60 msec            | Fast1                   | AVC Set1       | 2.1MHz         | 525KHz                  | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 61h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 62h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 63h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set4       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 64h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set1       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 65h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 66h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 67h         | AVC Set4          | 1.05MHz       | 1.05MHz           |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     |                         |                     |                 |          |         |        |         |
| 68h         | Slow2             | 0.5 sec       | 60 msec           | 70 msec                  | 0.5 sec           | 70 msec     | 70 msec           | 70 msec        | 70 msec             | 70 msec            | Slow2                   | AVC Set1       | 2.1MHz         | 525KHz                  | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 69h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 6Ah         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 6Bh         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set4       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 6Ch         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set1       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 6Dh         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 6Eh         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 6Fh         | AVC Set4          | 1.05MHz       | 1.05MHz           |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     |                         |                     |                 |          |         |        |         |
| 70h         | Slow1             | 1.0 sec       | 70 msec           | 80 msec                  | 0.5 sec           | 80 msec     | 80 msec           | 80 msec        | 80 msec             | 80 msec            | Slow1                   | AVC Set1       | 2.1MHz         | 525KHz                  | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 71h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 72h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 73h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set4       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 74h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set1       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 75h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 76h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 77h         | AVC Set4          | 1.05MHz       | 1.05MHz           |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     |                         |                     |                 |          |         |        |         |
| 78h         | Fast1             | 1.0 sec       | 80 msec           | 90 msec                  | 0.5 sec           | 90 msec     | 90 msec           | 90 msec        | 90 msec             | 90 msec            | Fast1                   | AVC Set1       | 2.1MHz         | 525KHz                  | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 79h         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 7Ah         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 7Bh         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set4       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 7Ch         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set1       | 1.05MHz        |                         | 1.05MHz             |                     |                         |                     |                 |          |         |        |         |
| 7Dh         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set2       | 525KHz         |                         | 525KHz              |                     |                         |                     |                 |          |         |        |         |
| 7Eh         |                   |               |                   |                          |                   |             |                   |                |                     |                    |                         | AVC Set3       | 2.1MHz         |                         | 2.1MHz              |                     |                         |                     |                 |          |         |        |         |
| 7Fh         | AVC Set4          | 1.05MHz       | 1.05MHz           |                          |                   |             |                   |                |                     |                    |                         |                |                |                         |                     |                     |                         |                     |                 |          |         |        |         |

Command Table – continued

| DATA (HEX)  | Register Address  |               |                   |                          |                   |             |                   |               |                     |                    |                         |                 |                  |                     |                         |                     |                      |                 |         |       |          |  |         |         |         |         |         |         |
|-------------|-------------------|---------------|-------------------|--------------------------|-------------------|-------------|-------------------|---------------|---------------------|--------------------|-------------------------|-----------------|------------------|---------------------|-------------------------|---------------------|----------------------|-----------------|---------|-------|----------|--|---------|---------|---------|---------|---------|---------|
|             | 09h               |               |                   | 0Ah                      |                   |             | 0Bh               |               |                     | 0Ch                |                         |                 | 0Dh              |                     |                         |                     |                      |                 |         |       |          |  |         |         |         |         |         |         |
| DataRef [7] | Delay3 time [6:4] | DoubleReg [3] | Delay2 time [2:0] | VGH Discharge Enable [7] | Delay5 time [6:4] | AR_Time [3] | Delay4 time [2:0] | AVDD COMP [7] | AVDD OCP Select [6] | AVDD SS time [5:4] | AVDD SW Slew Rate [3:2] | AVDD COIL [1:0] | Start-up Bit [7] | VGH mode select [6] | VGH+VGL Frequency [5:4] | VDD Frequency [3:2] | AVDD Frequency [1:0] | Check Sum [7:0] |         |       |          |  |         |         |         |         |         |         |
| 80h         | Enable            | Disable       | 0 msec            | Disable                  |                   | 0.5 sec     | 0 msec            | AV_COM P_Sel2 | 2.0 A               |                    | Slow2                   | AVC Set1        | Enable           | x3 mode             | 2.1MHz                  | 2.1MHz              | 2.1MHz               | 2.1MHz          | 2.1MHz  |       |          |  |         |         |         |         |         |         |
| 81h         |                   |               | 5 msec            |                          |                   |             | 5 msec            |               |                     |                    |                         | AVC Set2        |                  |                     | 1.05MHz                 |                     | 1.05MHz              |                 |         |       |          |  |         |         |         |         |         |         |
| 82h         |                   |               | 10 msec           |                          |                   |             | 10 msec           |               |                     |                    |                         | AVC Set3        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| 83h         |                   |               | 15 msec           |                          |                   |             | 15 msec           |               |                     |                    |                         | AVC Set4        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| 84h         |                   |               | 20 msec           |                          |                   |             | 20 msec           |               |                     |                    |                         | AVC Set1        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| 85h         |                   |               | 25 msec           |                          |                   |             | 25 msec           |               |                     |                    |                         | AVC Set2        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| 86h         |                   |               | 30 msec           |                          |                   |             | 30 msec           |               |                     |                    |                         | AVC Set3        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| 87h         |                   |               | 40 msec           |                          |                   |             | 40 msec           |               |                     |                    |                         | AVC Set4        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| 88h         |                   | Enable        | 0.5 sec           |                          |                   | 0 msec      | 0.5 sec           |               |                     |                    |                         | 1.0 sec         |                  |                     | 0 msec                  |                     |                      |                 |         | Slow1 | AVC Set1 |  | x3 mode | 2.1MHz  | 2.1MHz  | 2.1MHz  | 2.1MHz  | 2.1MHz  |
| 89h         |                   |               |                   |                          |                   | 5 msec      |                   |               |                     |                    |                         |                 |                  |                     | 5 msec                  |                     |                      |                 |         |       | AVC Set2 |  |         | 1.05MHz |         | 1.05MHz |         |         |
| 8Ah         |                   |               |                   |                          |                   | 10 msec     |                   |               |                     |                    |                         |                 |                  |                     | 10 msec                 |                     |                      |                 |         |       | AVC Set3 |  |         | 525KHz  |         | 525KHz  |         |         |
| 8Bh         |                   |               |                   |                          |                   | 15 msec     |                   |               |                     |                    |                         |                 |                  |                     | 15 msec                 |                     |                      |                 |         |       | AVC Set4 |  |         | 525KHz  |         | 525KHz  |         |         |
| 8Ch         |                   |               |                   |                          |                   | 20 msec     |                   |               |                     |                    |                         |                 |                  |                     | 20 msec                 |                     |                      |                 |         |       | AVC Set1 |  |         | 525KHz  |         | 525KHz  |         |         |
| 8Dh         |                   |               |                   |                          |                   | 25 msec     |                   |               |                     |                    |                         |                 |                  |                     | 25 msec                 |                     |                      |                 |         |       | AVC Set2 |  |         | 525KHz  |         | 525KHz  |         |         |
| 8Eh         |                   |               |                   |                          |                   | 30 msec     |                   |               |                     |                    |                         |                 |                  |                     | 30 msec                 |                     |                      |                 |         |       | AVC Set3 |  |         | 525KHz  |         | 525KHz  |         |         |
| 8Fh         |                   |               |                   |                          |                   | 40 msec     |                   |               |                     |                    |                         |                 |                  |                     | 40 msec                 |                     |                      |                 |         |       | AVC Set4 |  |         | 525KHz  |         | 525KHz  |         |         |
| 90h         | Enable            | Disable       | 0 msec            | Disable                  |                   | 2 msec      | 0 msec            | AV_COM P_Sel2 | 1.0 A               |                    | Slow2                   | AVC Set1        | Enable           | x2 mode             | 1.05MHz                 | 1.05MHz             | 1.05MHz              | 1.05MHz         | 1.05MHz |       |          |  |         |         |         |         |         |         |
| 91h         |                   |               | 5 msec            |                          |                   |             | 5 msec            |               |                     |                    |                         | AVC Set2        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| 92h         |                   |               | 10 msec           |                          |                   |             | 10 msec           |               |                     |                    |                         | AVC Set3        |                  |                     | 256KHz                  |                     | 256KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| 93h         |                   |               | 15 msec           |                          |                   |             | 15 msec           |               |                     |                    |                         | AVC Set4        |                  |                     | 256KHz                  |                     | 256KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| 94h         |                   |               | 20 msec           |                          |                   |             | 20 msec           |               |                     |                    |                         | AVC Set1        |                  |                     | 256KHz                  |                     | 256KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| 95h         |                   |               | 25 msec           |                          |                   |             | 25 msec           |               |                     |                    |                         | AVC Set2        |                  |                     | 256KHz                  |                     | 256KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| 96h         |                   |               | 30 msec           |                          |                   |             | 30 msec           |               |                     |                    |                         | AVC Set3        |                  |                     | 256KHz                  |                     | 256KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| 97h         |                   |               | 40 msec           |                          |                   |             | 40 msec           |               |                     |                    |                         | AVC Set4        |                  |                     | 256KHz                  |                     | 256KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| 98h         |                   | Enable        | 0.5 sec           |                          |                   | 0 msec      | 0.5 sec           |               |                     |                    |                         | 1.0 sec         |                  |                     | 0 msec                  |                     |                      |                 |         | Slow1 | AVC Set1 |  | x2 mode | 1.05MHz | 1.05MHz | 1.05MHz | 1.05MHz | 1.05MHz |
| 99h         |                   |               |                   |                          |                   | 5 msec      |                   |               |                     |                    |                         |                 |                  |                     | 5 msec                  |                     |                      |                 |         |       | AVC Set2 |  |         | 525KHz  |         | 525KHz  |         |         |
| 9Ah         |                   |               |                   |                          |                   | 10 msec     |                   |               |                     |                    |                         |                 |                  |                     | 10 msec                 |                     |                      |                 |         |       | AVC Set3 |  |         | 256KHz  |         | 256KHz  |         |         |
| 9Bh         |                   |               |                   |                          |                   | 15 msec     |                   |               |                     |                    |                         |                 |                  |                     | 15 msec                 |                     |                      |                 |         |       | AVC Set4 |  |         | 256KHz  |         | 256KHz  |         |         |
| 9Ch         |                   |               |                   |                          |                   | 20 msec     |                   |               |                     |                    |                         |                 |                  |                     | 20 msec                 |                     |                      |                 |         |       | AVC Set1 |  |         | 256KHz  |         | 256KHz  |         |         |
| 9Dh         |                   |               |                   |                          |                   | 25 msec     |                   |               |                     |                    |                         |                 |                  |                     | 25 msec                 |                     |                      |                 |         |       | AVC Set2 |  |         | 256KHz  |         | 256KHz  |         |         |
| 9Eh         |                   |               |                   |                          |                   | 30 msec     |                   |               |                     |                    |                         |                 |                  |                     | 30 msec                 |                     |                      |                 |         |       | AVC Set3 |  |         | 256KHz  |         | 256KHz  |         |         |
| 9Fh         |                   |               |                   |                          |                   | 40 msec     |                   |               |                     |                    |                         |                 |                  |                     | 40 msec                 |                     |                      |                 |         |       | AVC Set4 |  |         | 256KHz  |         | 256KHz  |         |         |
| A0h         | Enable            | Disable       | 0 msec            | Disable                  |                   | 4 msec      | 0 msec            | AV_COM P_Sel2 | 2.0 A               |                    | Slow2                   | AVC Set1        | Enable           | x3 mode             | 525KHz                  | 2.1MHz              | 2.1MHz               | 2.1MHz          | 2.1MHz  |       |          |  |         |         |         |         |         |         |
| A1h         |                   |               | 5 msec            |                          |                   |             | 5 msec            |               |                     |                    |                         | AVC Set2        |                  |                     | 256KHz                  |                     | 256KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| A2h         |                   |               | 10 msec           |                          |                   |             | 10 msec           |               |                     |                    |                         | AVC Set3        |                  |                     | 128KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| A3h         |                   |               | 15 msec           |                          |                   |             | 15 msec           |               |                     |                    |                         | AVC Set4        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| A4h         |                   |               | 20 msec           |                          |                   |             | 20 msec           |               |                     |                    |                         | AVC Set1        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| A5h         |                   |               | 25 msec           |                          |                   |             | 25 msec           |               |                     |                    |                         | AVC Set2        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| A6h         |                   |               | 30 msec           |                          |                   |             | 30 msec           |               |                     |                    |                         | AVC Set3        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| A7h         |                   |               | 40 msec           |                          |                   |             | 40 msec           |               |                     |                    |                         | AVC Set4        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| A8h         |                   | Enable        | 0.5 sec           |                          |                   | 0 msec      | 0.5 sec           |               |                     |                    |                         | 1.0 sec         |                  |                     | 0 msec                  |                     |                      |                 |         | Slow1 | AVC Set1 |  | x3 mode | 2.1MHz  | 2.1MHz  | 2.1MHz  | 2.1MHz  | 2.1MHz  |
| A9h         |                   |               |                   |                          |                   | 5 msec      |                   |               |                     |                    |                         |                 |                  |                     | 5 msec                  |                     |                      |                 |         |       | AVC Set2 |  |         | 256KHz  |         | 256KHz  |         |         |
| AAh         |                   |               |                   |                          |                   | 10 msec     |                   |               |                     |                    |                         |                 |                  |                     | 10 msec                 |                     |                      |                 |         |       | AVC Set3 |  |         | 128KHz  |         | 525KHz  |         |         |
| ABh         |                   |               |                   |                          |                   | 15 msec     |                   |               |                     |                    |                         |                 |                  |                     | 15 msec                 |                     |                      |                 |         |       | AVC Set4 |  |         | 525KHz  |         | 525KHz  |         |         |
| ACh         |                   |               |                   |                          |                   | 20 msec     |                   |               |                     |                    |                         |                 |                  |                     | 20 msec                 |                     |                      |                 |         |       | AVC Set1 |  |         | 525KHz  |         | 525KHz  |         |         |
| ADh         |                   |               |                   |                          |                   | 25 msec     |                   |               |                     |                    |                         |                 |                  |                     | 25 msec                 |                     |                      |                 |         |       | AVC Set2 |  |         | 525KHz  |         | 525KHz  |         |         |
| AEh         |                   |               |                   |                          |                   | 30 msec     |                   |               |                     |                    |                         |                 |                  |                     | 30 msec                 |                     |                      |                 |         |       | AVC Set3 |  |         | 525KHz  |         | 525KHz  |         |         |
| AFh         |                   |               |                   |                          |                   | 40 msec     |                   |               |                     |                    |                         |                 |                  |                     | 40 msec                 |                     |                      |                 |         |       | AVC Set4 |  |         | 525KHz  |         | 525KHz  |         |         |
| B0h         | Enable            | Disable       | 0 msec            | Disable                  |                   | 6 msec      | 0 msec            | AV_COM P_Sel2 | 1.0 A               |                    | Slow2                   | AVC Set1        | Enable           | x2 mode             | 525KHz                  | 2.1MHz              | 2.1MHz               | 2.1MHz          | 2.1MHz  |       |          |  |         |         |         |         |         |         |
| B1h         |                   |               | 5 msec            |                          |                   |             | 5 msec            |               |                     |                    |                         | AVC Set2        |                  |                     | 256KHz                  |                     | 256KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| B2h         |                   |               | 10 msec           |                          |                   |             | 10 msec           |               |                     |                    |                         | AVC Set3        |                  |                     | 128KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| B3h         |                   |               | 15 msec           |                          |                   |             | 15 msec           |               |                     |                    |                         | AVC Set4        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| B4h         |                   |               | 20 msec           |                          |                   |             | 20 msec           |               |                     |                    |                         | AVC Set1        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| B5h         |                   |               | 25 msec           |                          |                   |             | 25 msec           |               |                     |                    |                         | AVC Set2        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| B6h         |                   |               | 30 msec           |                          |                   |             | 30 msec           |               |                     |                    |                         | AVC Set3        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| B7h         |                   |               | 40 msec           |                          |                   |             | 40 msec           |               |                     |                    |                         | AVC Set4        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| B8h         |                   | Enable        | 0.5 sec           |                          |                   | 0 msec      | 0.5 sec           |               |                     |                    |                         | 1.0 sec         |                  |                     | 0 msec                  |                     |                      |                 |         | Slow1 | AVC Set1 |  | x2 mode | 2.1MHz  | 2.1MHz  | 2.1MHz  | 2.1MHz  | 2.1MHz  |
| B9h         |                   |               |                   |                          |                   | 5 msec      |                   |               |                     |                    |                         |                 |                  |                     | 5 msec                  |                     |                      |                 |         |       | AVC Set2 |  |         | 256KHz  |         | 256KHz  |         |         |
| BAh         |                   |               |                   |                          |                   | 10 msec     |                   |               |                     |                    |                         |                 |                  |                     | 10 msec                 |                     |                      |                 |         |       | AVC Set3 |  |         | 128KHz  |         | 525KHz  |         |         |
| BBh         |                   |               |                   |                          |                   | 15 msec     |                   |               |                     |                    |                         |                 |                  |                     | 15 msec                 |                     |                      |                 |         |       | AVC Set4 |  |         | 525KHz  |         | 525KHz  |         |         |
| BCh         |                   |               |                   |                          |                   | 20 msec     |                   |               |                     |                    |                         |                 |                  |                     | 20 msec                 |                     |                      |                 |         |       | AVC Set1 |  |         | 525KHz  |         | 525KHz  |         |         |
| BDh         |                   |               |                   |                          |                   | 25 msec     |                   |               |                     |                    |                         |                 |                  |                     | 25 msec                 |                     |                      |                 |         |       | AVC Set2 |  |         | 525KHz  |         | 525KHz  |         |         |
| BEh         |                   |               |                   |                          |                   | 30 msec     |                   |               |                     |                    |                         |                 |                  |                     | 30 msec                 |                     |                      |                 |         |       | AVC Set3 |  |         | 525KHz  |         | 525KHz  |         |         |
| BFh         |                   |               |                   |                          |                   | 40 msec     |                   |               |                     |                    |                         |                 |                  |                     | 40 msec                 |                     |                      |                 |         |       | AVC Set4 |  |         | 525KHz  |         | 525KHz  |         |         |
| C0h         | Enable            | Disable       | 0 msec            | Disable                  |                   | 8 msec      | 0 msec            | AV_COM P_Sel2 | 2.0 A               |                    | Slow2                   | AVC Set1        | Enable           | x3 mode             | 2.1MHz                  | 2.1MHz              | 2.1MHz               | 2.1MHz          | 2.1MHz  |       |          |  |         |         |         |         |         |         |
| C1h         |                   |               | 5 msec            |                          |                   |             | 5 msec            |               |                     |                    |                         | AVC Set2        |                  |                     | 1.05MHz                 |                     | 1.05MHz              |                 |         |       |          |  |         |         |         |         |         |         |
| C2h         |                   |               | 10 msec           |                          |                   |             | 10 msec           |               |                     |                    |                         | AVC Set3        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| C3h         |                   |               | 15 msec           |                          |                   |             | 15 msec           |               |                     |                    |                         | AVC Set4        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| C4h         |                   |               | 20 msec           |                          |                   |             | 20 msec           |               |                     |                    |                         | AVC Set1        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| C5h         |                   |               | 25 msec           |                          |                   |             | 25 msec           |               |                     |                    |                         | AVC Set2        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| C6h         |                   |               | 30 msec           |                          |                   |             | 30 msec           |               |                     |                    |                         | AVC Set3        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| C7h         |                   |               | 40 msec           |                          |                   |             | 40 msec           |               |                     |                    |                         | AVC Set4        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| C8h         |                   | Enable        | 0.5 sec           |                          |                   | 0 msec      | 0.5 sec           |               |                     |                    |                         | 1.0 sec         |                  |                     | 0 msec                  |                     |                      |                 |         | Slow1 | AVC Set1 |  | x3 mode | 2.1MHz  | 2.1MHz  | 2.1MHz  | 2.1MHz  | 2.1MHz  |
| C9h         |                   |               |                   |                          |                   | 5 msec      |                   |               |                     |                    |                         |                 |                  |                     | 5 msec                  |                     |                      |                 |         |       | AVC Set2 |  |         | 1.05MHz |         | 1.05MHz |         |         |
| CAh         |                   |               |                   |                          |                   | 10 msec     |                   |               |                     |                    |                         |                 |                  |                     | 10 msec                 |                     |                      |                 |         |       | AVC Set3 |  |         | 525KHz  |         | 525KHz  |         |         |
| CBh         |                   |               |                   |                          |                   | 15 msec     |                   |               |                     |                    |                         |                 |                  |                     | 15 msec                 |                     |                      |                 |         |       | AVC Set4 |  |         | 525KHz  |         | 525KHz  |         |         |
| CCh         |                   |               |                   |                          |                   | 20 msec     |                   |               |                     |                    |                         |                 |                  |                     | 20 msec                 |                     |                      |                 |         |       | AVC Set1 |  |         | 525KHz  |         | 525KHz  |         |         |
| CDh         |                   |               |                   |                          |                   | 25 msec     |                   |               |                     |                    |                         |                 |                  |                     | 25 msec                 |                     |                      |                 |         |       | AVC Set2 |  |         | 525KHz  |         | 525KHz  |         |         |
| CEh         |                   |               |                   |                          |                   | 30 msec     |                   |               |                     |                    |                         |                 |                  |                     | 30 msec                 |                     |                      |                 |         |       | AVC Set3 |  |         | 525KHz  |         | 525KHz  |         |         |
| CFh         |                   |               |                   |                          |                   | 40 msec     |                   |               |                     |                    |                         |                 |                  |                     | 40 msec                 |                     |                      |                 |         |       | AVC Set4 |  |         | 525KHz  |         | 525KHz  |         |         |
| D0h         | Enable            | Disable       | 0 msec            | Disable                  |                   | 10 msec     | 0 msec            | AV_COM P_Sel2 | 1.0 A               |                    | Slow2                   | AVC Set1        | Enable           | x2 mode             | 1.05MHz                 | 2.1MHz              | 1.05MHz              | 1.05MHz         | 1.05MHz |       |          |  |         |         |         |         |         |         |
| D1h         |                   |               | 5 msec            |                          |                   |             | 5 msec            |               |                     |                    |                         | AVC Set2        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| D2h         |                   |               | 10 msec           |                          |                   |             | 10 msec           |               |                     |                    |                         | AVC Set3        |                  |                     | 256KHz                  |                     | 256KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| D3h         |                   |               | 15 msec           |                          |                   |             | 15 msec           |               |                     |                    |                         | AVC Set4        |                  |                     | 256KHz                  |                     | 256KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| D4h         |                   |               | 20 msec           |                          |                   |             | 20 msec           |               |                     |                    |                         | AVC Set1        |                  |                     | 256KHz                  |                     | 256KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| D5h         |                   |               | 25 msec           |                          |                   |             | 25 msec           |               |                     |                    |                         | AVC Set2        |                  |                     | 256KHz                  |                     | 256KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| D6h         |                   |               | 30 msec           |                          |                   |             | 30 msec           |               |                     |                    |                         | AVC Set3        |                  |                     | 256KHz                  |                     | 256KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| D7h         |                   |               | 40 msec           |                          |                   |             | 40 msec           |               |                     |                    |                         | AVC Set4        |                  |                     | 256KHz                  |                     | 256KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| D8h         |                   | Enable        | 0.5 sec           |                          |                   | 0 msec      | 0.5 sec           |               |                     |                    |                         | 1.0 sec         |                  |                     | 0 msec                  |                     |                      |                 |         | Slow1 | AVC Set1 |  | x2 mode | 2.1MHz  | 2.1MHz  | 2.1MHz  | 2.1MHz  | 2.1MHz  |
| D9h         |                   |               |                   |                          |                   | 5 msec      |                   |               |                     |                    |                         |                 |                  |                     | 5 msec                  |                     |                      |                 |         |       | AVC Set2 |  |         | 1.05MHz |         | 1.05MHz |         |         |
| DAh         |                   |               |                   |                          |                   | 10 msec     |                   |               |                     |                    |                         |                 |                  |                     | 10 msec                 |                     |                      |                 |         |       | AVC Set3 |  |         | 525KHz  |         | 525KHz  |         |         |
| DBh         |                   |               |                   |                          |                   | 15 msec     |                   |               |                     |                    |                         |                 |                  |                     | 15 msec                 |                     |                      |                 |         |       | AVC Set4 |  |         | 525KHz  |         | 525KHz  |         |         |
| DC          |                   |               |                   |                          |                   | 20 msec     |                   |               |                     |                    |                         |                 |                  |                     | 20 msec                 |                     |                      |                 |         |       | AVC Set1 |  |         | 525KHz  |         | 525KHz  |         |         |
| DDh         |                   |               |                   |                          |                   | 25 msec     |                   |               |                     |                    |                         |                 |                  |                     | 25 msec                 |                     |                      |                 |         |       | AVC Set2 |  |         | 525KHz  |         | 525KHz  |         |         |
| DEh         |                   |               |                   |                          |                   | 30 msec     |                   |               |                     |                    |                         |                 |                  |                     | 30 msec                 |                     |                      |                 |         |       | AVC Set3 |  |         | 525KHz  |         | 525KHz  |         |         |
| DFh         |                   |               |                   |                          |                   | 40 msec     |                   |               |                     |                    |                         |                 |                  |                     | 40 msec                 |                     |                      |                 |         |       | AVC Set4 |  |         | 525KHz  |         | 525KHz  |         |         |
| E0h         | Enable            | Disable       | 0 msec            | Disable                  |                   | 15 msec     | 0 msec            | AV_COM P_Sel2 | 2.0 A               |                    | Slow2                   | AVC Set1        | Enable           | x3 mode             | 525KHz                  | 2.1MHz              | 525KHz               | 525KHz          | 525KHz  |       |          |  |         |         |         |         |         |         |
| E1h         |                   |               | 5 msec            |                          |                   |             | 5 msec            |               |                     |                    |                         | AVC Set2        |                  |                     | 256KHz                  |                     | 256KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| E2h         |                   |               | 10 msec           |                          |                   |             | 10 msec           |               |                     |                    |                         | AVC Set3        |                  |                     | 128KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| E3h         |                   |               | 15 msec           |                          |                   |             | 15 msec           |               |                     |                    |                         | AVC Set4        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| E4h         |                   |               | 20 msec           |                          |                   |             | 20 msec           |               |                     |                    |                         | AVC Set1        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| E5h         |                   |               | 25 msec           |                          |                   |             | 25 msec           |               |                     |                    |                         | AVC Set2        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| E6h         |                   |               | 30 msec           |                          |                   |             | 30 msec           |               |                     |                    |                         | AVC Set3        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| E7h         |                   |               | 40 msec           |                          |                   |             | 40 msec           |               |                     |                    |                         | AVC Set4        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| E8h         |                   | Enable        | 0.5 sec           |                          |                   | 0 msec      | 0.5 sec           |               |                     |                    |                         | 1.0 sec         |                  |                     | 0 msec                  |                     |                      |                 |         | Slow1 | AVC Set1 |  | x3 mode | 2.1MHz  | 2.1MHz  | 2.1MHz  | 2.1MHz  | 2.1MHz  |
| E9h         |                   |               |                   |                          |                   | 5 msec      |                   |               |                     |                    |                         |                 |                  |                     | 5 msec                  |                     |                      |                 |         |       | AVC Set2 |  |         | 1.05MHz |         | 1.05MHz |         |         |
| EAh         |                   |               |                   |                          |                   | 10 msec     |                   |               |                     |                    |                         |                 |                  |                     | 10 msec                 |                     |                      |                 |         |       | AVC Set3 |  |         | 525KHz  |         | 525KHz  |         |         |
| ECh         |                   |               |                   |                          |                   | 15 msec     |                   |               |                     |                    |                         |                 |                  |                     | 15 msec                 |                     |                      |                 |         |       | AVC Set4 |  |         | 525KHz  |         | 525KHz  |         |         |
| EDh         |                   |               |                   |                          |                   | 20 msec     |                   |               |                     |                    |                         |                 |                  |                     | 20 msec                 |                     |                      |                 |         |       | AVC Set1 |  |         | 525KHz  |         | 525KHz  |         |         |
| EEh         |                   |               |                   |                          |                   | 25 msec     |                   |               |                     |                    |                         |                 |                  |                     | 25 msec                 |                     |                      |                 |         |       | AVC Set2 |  |         | 525KHz  |         | 525KHz  |         |         |
| EFh         |                   |               |                   |                          |                   | 30 msec     |                   |               |                     |                    |                         |                 |                  |                     | 30 msec                 |                     |                      |                 |         |       | AVC Set3 |  |         | 525KHz  |         | 525KHz  |         |         |
| EFh         |                   |               |                   |                          |                   | 40 msec     |                   |               |                     |                    |                         |                 |                  |                     | 40 msec                 |                     |                      |                 |         |       | AVC Set4 |  |         | 525KHz  |         | 525KHz  |         |         |
| F0h         | Enable            | Disable       | 0 msec            | Disable                  |                   | 20 msec     | 0 msec            | AV_COM P_Sel2 | 1.0 A               |                    | Slow2                   | AVC Set1        | Enable           | x2 mode             | 525KHz                  | 2.1MHz              | 525KHz               | 525KHz          | 525KHz  |       |          |  |         |         |         |         |         |         |
| F1h         |                   |               | 5 msec            |                          |                   |             | 5 msec            |               |                     |                    |                         | AVC Set2        |                  |                     | 256KHz                  |                     | 256KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| F2h         |                   |               | 10 msec           |                          |                   |             | 10 msec           |               |                     |                    |                         | AVC Set3        |                  |                     | 128KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| F3h         |                   |               | 15 msec           |                          |                   |             | 15 msec           |               |                     |                    |                         | AVC Set4        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| F4h         |                   |               | 20 msec           |                          |                   |             | 20 msec           |               |                     |                    |                         | AVC Set1        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| F5h         |                   |               | 25 msec           |                          |                   |             | 25 msec           |               |                     |                    |                         | AVC Set2        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| F6h         |                   |               | 30 msec           |                          |                   |             | 30 msec           |               |                     |                    |                         | AVC Set3        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| F7h         |                   |               | 40 msec           |                          |                   |             | 40 msec           |               |                     |                    |                         | AVC Set4        |                  |                     | 525KHz                  |                     | 525KHz               |                 |         |       |          |  |         |         |         |         |         |         |
| F8h         |                   | Enable        | 0.5 sec           |                          |                   | 0 msec      | 0.5 sec           |               |                     |                    |                         | 1.0 sec         |                  |                     | 0 msec                  |                     |                      |                 |         | Slow1 | AVC Set1 |  | x2 mode | 2.1MHz  | 2.1MHz  | 2.1MHz  | 2.1MHz  | 2.1MHz  |
| F9h         |                   |               |                   |                          |                   | 5 msec      |                   |               |                     |                    |                         |                 |                  |                     | 5 msec                  |                     |                      |                 |         |       | AVC Set2 |  |         | 1.05MHz |         | 1.05MHz |         |         |
| FAh         |                   |               |                   |                          |                   | 10 msec     |                   |               |                     |                    |                         |                 |                  |                     | 10 msec                 |                     |                      |                 |         |       | AVC Set3 |  |         | 525KHz  |         | 525KHz  |         |         |
| FBh         |                   |               |                   |                          |                   | 15 msec     |                   |               |                     |                    |                         |                 |                  |                     | 15 msec                 |                     |                      |                 |         |       | AVC Set4 |  |         | 525KHz  |         | 525KHz  |         |         |
| FCh         |                   |               |                   |                          |                   | 20 msec     |                   |               |                     |                    |                         |                 |                  |                     | 20 msec                 |                     |                      |                 |         |       | AVC Set1 |  |         | 525KHz  |         | 525KHz  |         |         |
| FDh         |                   |               |                   |                          |                   | 25 msec     |                   |               |                     |                    |                         |                 |                  |                     | 25 msec                 |                     |                      |                 |         |       | AVC Set2 |  |         | 525KHz  |         | 525KHz  |         |         |
| FEh         |                   |               |                   |                          |                   | 30 msec     |                   |               |                     |                    |                         |                 |                  |                     | 30 msec                 |                     |                      |                 |         |       | AVC Set3 |  |         | 525KHz  |         | 525KHz  |         |         |
| FEh         |                   |               |                   |                          |                   | 40 msec     |                   |               |                     |                    |                         |                 |                  |                     | 40 msec                 |                     |                      |                 |         |       | AVC Set4 |  |         | 525KHz  |         | 525KHz  |         |         |

**Check Sum**

Check Sum which has been adopted in BM81810MUV-M is shown below.  
 You will calculate the Check Sum that the sum of the data, including the Check Sum(CHK7 to CHK0) is 00h.

| Register | [7]  | [6]  | [5]  | [4]  | [3]  | [2]  | [1]  | [0]  |
|----------|------|------|------|------|------|------|------|------|
| 00h      | A7   | A6   | A5   | A4   | A3   | A2   | A1   | A0   |
| 01h      | B7   | B6   | B5   | B4   | B3   | B2   | B1   | B0   |
| 02h      | C7   | C6   | C5   | C4   | C3   | C2   | C1   | C0   |
| 03h      | D7   | D6   | D5   | D4   | D3   | D2   | D1   | D0   |
| 04h      | E7   | E6   | E5   | E4   | E3   | E2   | E1   | E0   |
| 05h      | F7   | F6   | F5   | F4   | F3   | F2   | F1   | F0   |
| 06h      | G7   | G6   | G5   | G4   | G3   | G2   | G1   | G0   |
| 07h      | H7   | H6   | H5   | H4   | H3   | H2   | H1   | H0   |
| 08h      | I7   | I6   | I5   | I4   | I3   | I2   | I1   | I0   |
| 09h      | J7   | J6   | J5   | J4   | J3   | J2   | J1   | J0   |
| 0Ah      | K7   | K6   | K5   | K4   | K3   | K2   | K1   | K0   |
| 0Bh      | L7   | L6   | L5   | L4   | L3   | L2   | L1   | L0   |
| 0Ch      | M7   | M6   | M5   | M4   | M3   | M2   | M1   | M0   |
| 0Dh      | CHK7 | CHK6 | CHK5 | CHK4 | CHK3 | CHK2 | CHK1 | CHK0 |

$$[A7:A0] + [B7:B0] + [C7:C0] + [D7:D0] + [E7:E0] + [F7:F0] + [G7:G0] + [H7:H0] + [I7:I0] + [J7:J0] + [K7:K0] + [L7:L0] + [M7:M0] + [CHK7:CHK0] = 00h$$

**Soft Start Time**

BM81810MUV-M has soft start function on AVDD, VGH, VGL and VDD.  
 Time of the soft start is up to the output voltage reaches the typ Value.  
 The output voltage typ Value of each block is shown in the following table.

| BLOCK | Soft Start Output Voltage Typ Value | Soft Start Time |
|-------|-------------------------------------|-----------------|
| AVDD  | 10.5 V                              | Set Register    |
| VGH   | 18.0 V                              | 5 msec          |
| VGL   | -6.0 V                              | 5 msec          |
| VDD   | 1.2 V                               | 1 msec          |

The time setting Soft Start of AVDD is shown in the table below.

| Bit |   | AVDD Soft Start Time |
|-----|---|----------------------|
| 0   | 0 | 5 msec               |
| 0   | 1 | 10 msec              |
| 1   | 0 | 15 msec              |
| 1   | 1 | 20 msec              |

The soft-start time of VGH and VGL are 5msec.  
 The soft-start time of VDD is 1msec.

The soft-start setting an example of AVDD and VGH are shown in the figure below.

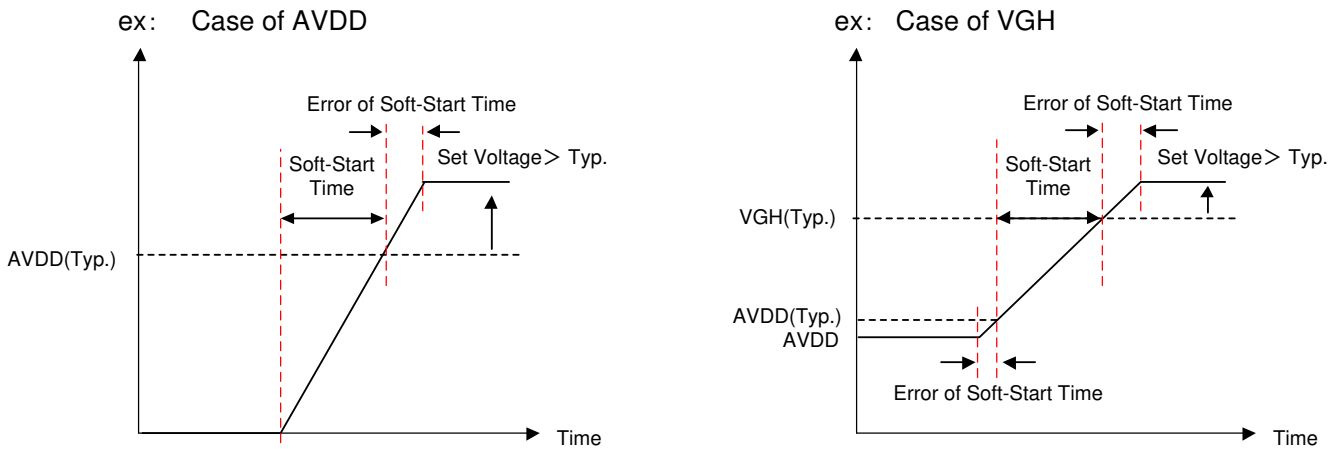


Figure 76. Soft-Start Time

If you change the setting voltage from typ values, occurs error in the soft-start time.

- The setting voltage > Typ Value ... Soft-start will be more slow.
- The setting voltage < Typ Value ... Soft-start will be more faster.

No error of soft-start is occurred for change of frequency.

Block Diagram

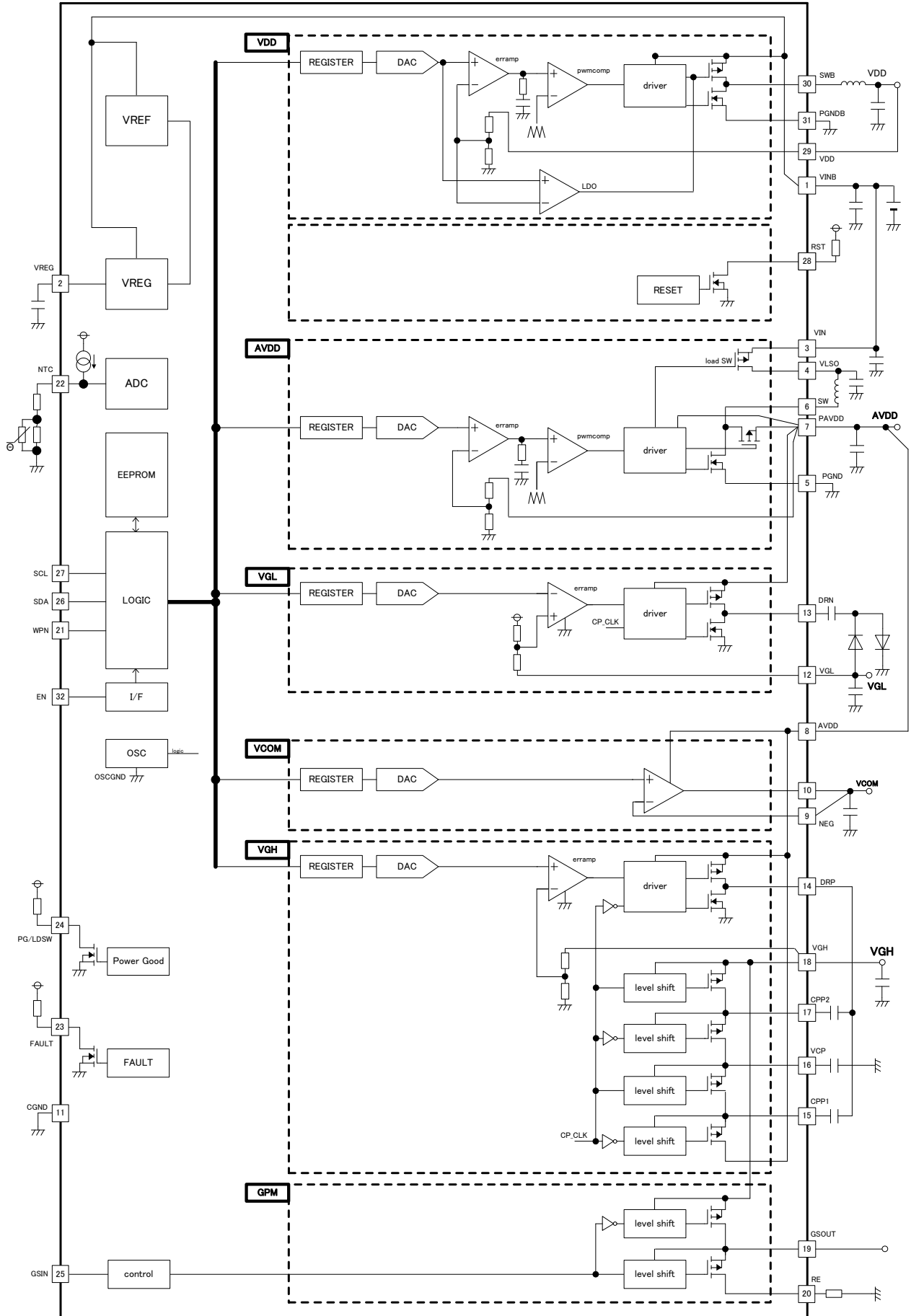


Figure 77. Block Diagram

AVDD Block Function

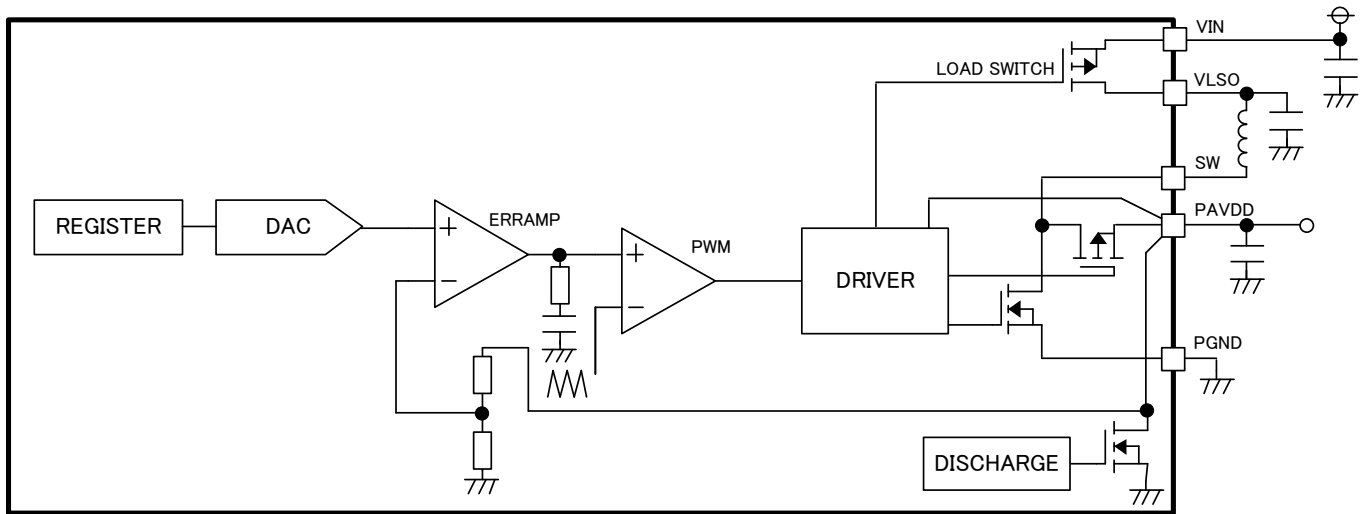


Figure 78. AVDD Block Diagram

AVDD Block (Boost DC / DC) can set the following functions by EEPROM.

1. AVDD Voltage (Register Address 00h [7:0])  
AVDD voltage can be set in 0.1V step from 5.0V to 17.0V.
2. SW Switching Frequency (Register Address 0Ch [1:0])  
The switching frequency can be set at 525KHz, 1.05MHz or 2.1MHz.
3. Soft Start Time (Register Address 0Bh [5:4])  
Soft Start Time of AVDD can be set in 5msec step from 5msec to 20msec.
4. SW Switching Slew Rate (Register Address 0Bh [3:2])  
SW pin switching Slew Rate can be controlled by the register setting.  
11'b is the fastest slew rate setting, 00'b is the slowest slew rate setting.

The slew rate by each setting is as follows.

Slew Rate changes by the external part and load electric current conditions such as a coil or the diode, but adjustment is possible on a true set condition because Slew Rate changes by Slew Rate setting change like Figure. 79.

The EMI properties are improved by slowing a slew rate, but please do enough evaluations after a slew rate change because efficiency becomes the tendency to decrease.

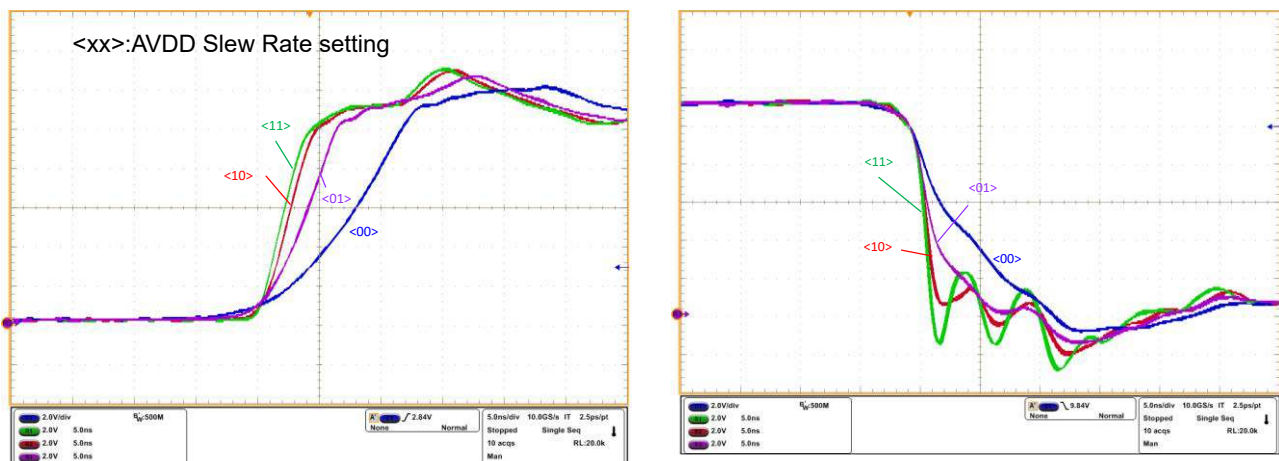


Figure 79. AVDD Switching Slew Rate  
(VIN=3.3V, AVDD=10.5V, Freq=2.1MHz, L=4.7μH, IAVDD=100mA)



AVDD Block Function - continued

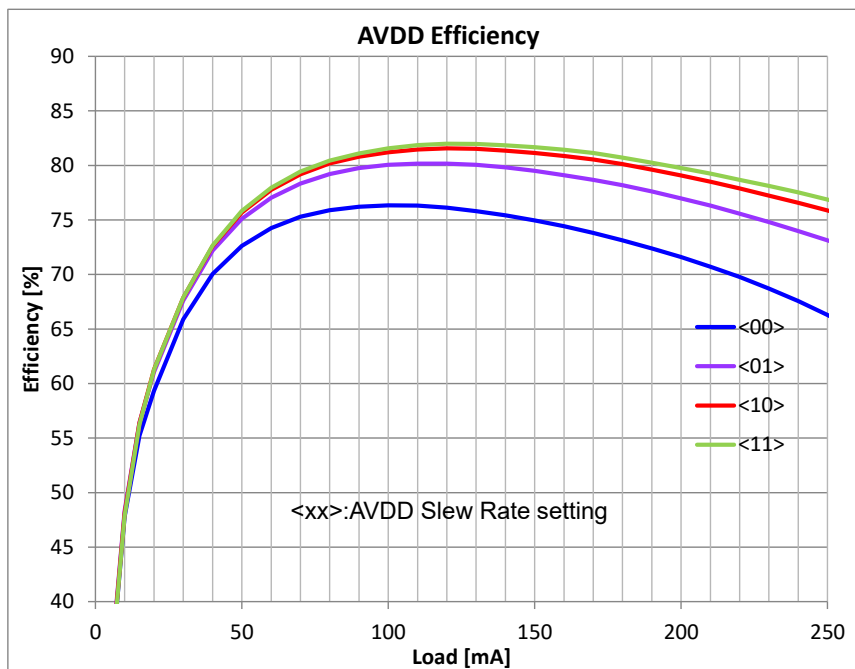


Figure 80. AVDD Efficiency (dependent on Slew Rate)  
 (VIN=3.3V, AVDD=10.5V, Freq=2.1MHz, L=4.7μH, IAVDD=100mA)

- 5. OCP Detect Level (Register Address 0Bh [6])  
 SW pin Over Current Protection detection level can be set at 1.0A(Min) or 2.0A(Min).
- 6. COMP Adjust (Register Address 0B [7])  
 Phase Margin can be adjusted.  
 0'b: AV\_COMP\_SET1  
 1'b: AV\_COMP\_SET2
- 7. COIL Adjust (Register Address 0Bh [1:0])  
 You can adjust the settings to match the coil constant to be used.  
 00'b:AV\_COIL\_SET1  
 01'b:AV\_COIL\_SET2  
 10'b:AV\_COIL\_SET3  
 11'b:AV\_COIL\_SET4

Please set the setting of COIL Adjust by frequency setting (fs) and a coil to use.

| f <sub>osc</sub> [kHz] | Coil[μH] | Coil Adjust 0Bh[1:0] | Comp Adjust 0Bh[7] |
|------------------------|----------|----------------------|--------------------|
| 525                    | 4.7      | 00'b                 | 0'b                |
| 525                    | 10       | 11'b                 | 0'b                |
| 1050                   | 4.7      | 00'b                 | 0'b                |
| 1050                   | 10       | 11'b                 | 0'b                |
| 2100                   | 4.7      | 00'b                 | 0'b                |
| 2100                   | 10       | 11'b                 | 0'b                |

\*Please become more than 10μF/25V product (GRT31CC81E106KE01) x3 with AVDD output capacitor at the time of the use with a coil of 10μH.

In addition, COMP Adjust coordinates phase constant of the ERRAMP output and is effective to shift to the zero point 25% low frequency side to produce by the ERRAMP output by making Comp Adjust 1'b and is effective in reducing ringing at the time of the load response by the responsiveness adjustment with the actual machine.

AVDD Block Function – continued

About the phase characteristic, please consider it based on enough evaluations with the actual model.

(1) Setting the Output L Constant (Boost Converter)

The coil to use for output is decided by the rating current  $I_{LR}$  and input current maximum value  $I_{INMAX}$  of the coil.

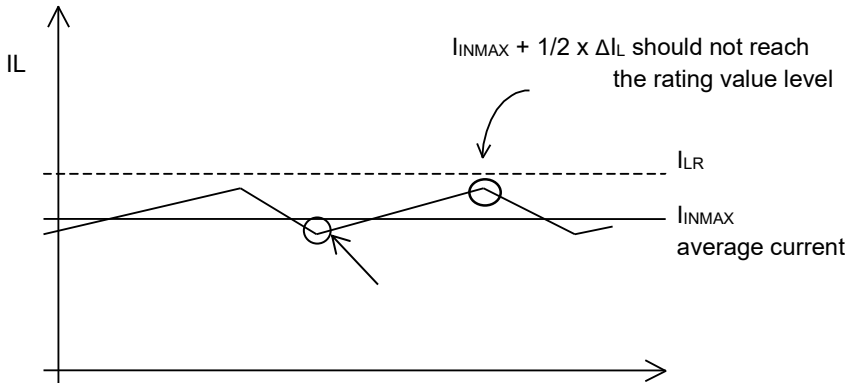


Figure 81. Coil Current Waveform

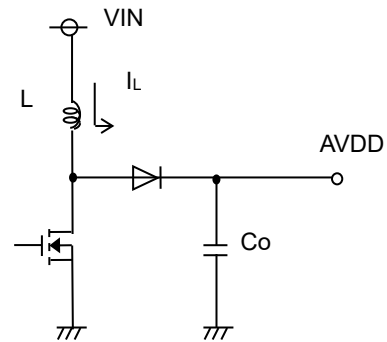


Figure 82. Output Application Circuit Diagram

Adjust so that  $I_{INMAX} + \Delta I_L$  does not reach the rating current value  $I_{LR}$ .  $\Delta I_L$  can be obtained by the following equation.

$$\Delta I_L = \frac{1}{L} \times V_{IN} \times \frac{AVDD - V_{IN}}{AVDD} \times \frac{1}{f} \quad [A] \quad \text{Here, } f \text{ is the switching frequency.}$$

Set with sufficient margin because the coil value may have the dispersion of  $\pm 30\%$ . If the coil current exceeds the rating current  $I_{LR}$  of the coil, it may damage the IC internal element.

BM81810MUV-M uses the current mode DC/DC converter control and has the optimized design at the coil value. A coil inductance (L) of 4.7  $\mu H$  to 10  $\mu H$  is recommended from viewpoints of electric power efficiency, response, and stability.

(2) Output Capacity Settings

For the capacitor to use for the output, select the capacitor which has the larger value in the ripple voltage  $V_{PP}$  allowance value and the drop voltage allowance value at the time of sudden load change. Output ripple voltage is decided by the following equation.

$$\Delta V_{PP} = I_{LMAX} \times R_{ESR} + \frac{1}{f C_o} \times \frac{V_{IN}}{AVDD} \times \left( I_{LMAX} - \frac{\Delta I_L}{2} \right) \quad [V]$$

Here, f is the switching frequency and  $R_{ESR}$  is ESR of output capacitor.

Perform setting so that the voltage is within the allowable ripple voltage range.

For the drop voltage during sudden load change;  $V_{DR}$ , please perform the rough calculation by the following equation.

$$V_{DR} = \frac{\Delta I}{C_o} \times 10 \mu s \quad [V]$$

However, 10  $\mu s$  is the rough calculation value of the DC/DC response speed. Please set the capacitance considering the sufficient margin so that these two values are within the standard value range.

(3) Selecting the Input Capacitor

Since the peak current flows between the input and output at the DC/DC converter, a capacitor is required to install at the input side. For the reason, the low ESR capacitor is recommended as an input capacitor which has the value more than 10  $\mu F$  and less than 100 m $\Omega$ . If a capacitor out of this range is selected, the excessive ripple voltage is superposed on the input voltage, accordingly it may cause the malfunction of IC.

However these conditions may vary according to the load current, input voltage, output voltage, inductance and switching frequency. Be sure to perform the margin check using the actual product.

VGH Block Function

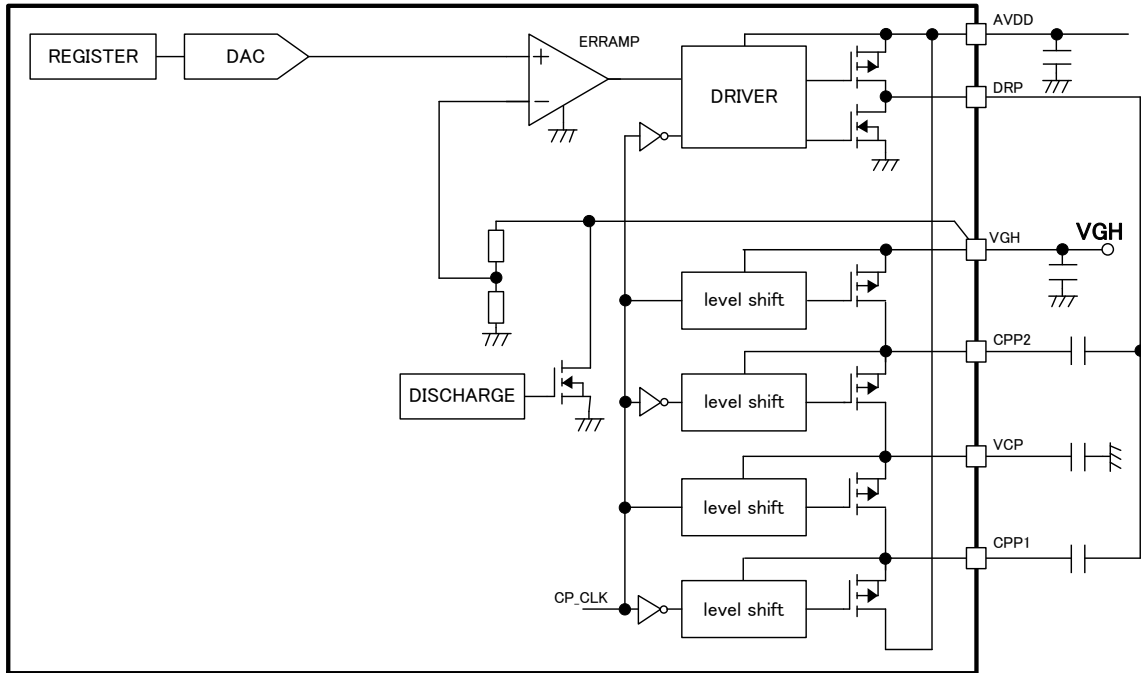


Figure 83. VGH Block Diagram

VGH Block (Positive Charge Pump) can set below functions by EEPROM.

1. VGH (HOT) Voltage (Register Address 01h [7:0])  
VGH (HOT) voltage can be set in 0.2V step from 8.0V to 35.0V.
2. DRP Switching Frequency (Register Address 0Ch [5:4])  
Switching frequency can be set at AVDD frequency x1, x1/2, or x1/4.
3. VGH (COLD) Voltage (Register Address 02h [6:0])  
To set VGH (COLD) voltage can have the VGH voltage relates to NTC Pin voltage, when NTC Function is used.  
VGH (COLD) voltage range can be set in 0.2V step from VGH (HOT) + 0V to VGH (HOT) + 15.0V.  
Refer "NTC Block Function" for the detail description of NTC Function.
4. VGH Mode Select (Register Address 0Ch [6])  
Boost Stage of Positive Charge Pump can be set by x2, x3, or x4.  
x2, x3 can be formed with internal element by EEPROM setting.  
x4 can be formed by connecting with external Diode.  
Since this function switch needs to change the application construction,  
input writing signal by I2C cannot perform Register writing.  
To write this Register setting, start-up bit(REG0Ch[7]) should be "0".

The VGH voltage output range with the AVDD voltage is related, and may take UVP without being able to output the VGH voltage of the setting when do not choose appropriate constitution.  
Please choose appropriate constitution referring after the following pages.

5. VGH Discharge enable (Register Address 0Ah [7])  
When OFF sequence, VGH pin Discharge function can be Enable/Disable.  
This function is to confirm when IC starts to operate. If read-and-write is performed after IC starts, the first time OFF sequence will not be reflected.

**VGH Block Function - continued**

**Application Example for VGH (3<sup>rd</sup> Stage Positive Charge Pump)**

Depending on the circuit construction, output voltage range of Charge Pump can be limited.

Besides, increasing VGH negative current can lower the possible output voltage.  
Please consider the actual application need to select appropriate circuit construction.

Below Figure shows the circuit construction of 3<sup>rd</sup> Stage Positive Charge Pump.  
Under this circuit, the possible setting range of VGH output voltage is  $(AVDD + 2) V$  to  $(AVDD \times 3 - 2) V$ .  
(When VGH negative current is 0mA)

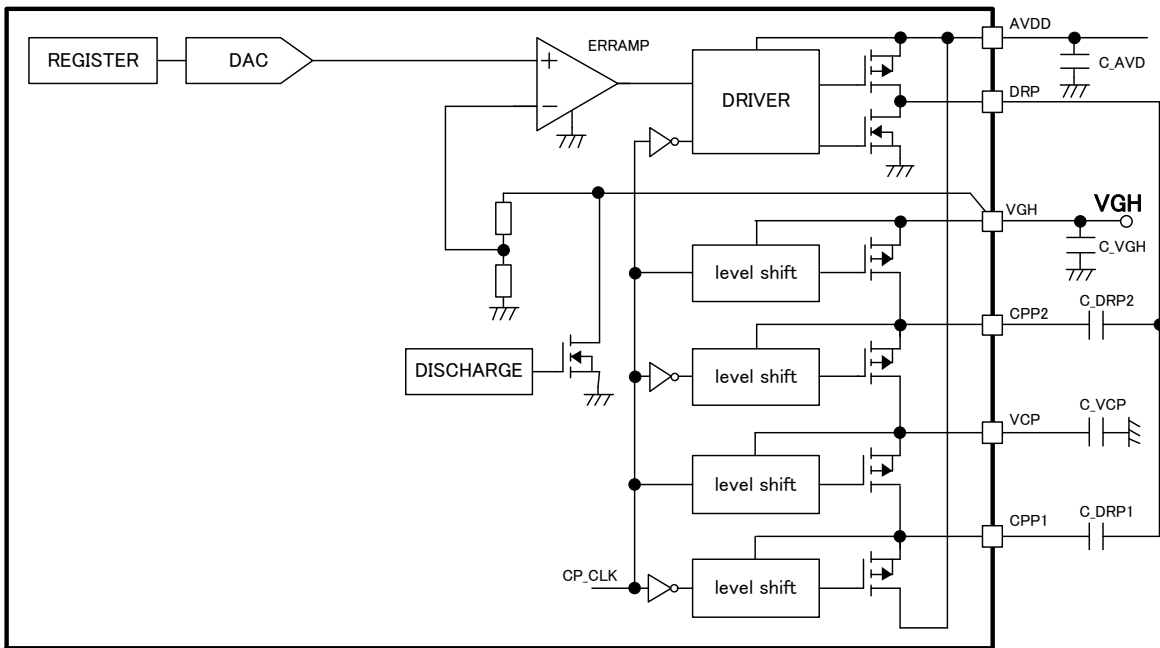


Figure 84. 3<sup>rd</sup> Stage Positive Charge Pump

**Application Example for VGH (2<sup>nd</sup> Stage Positive Charge Pump)**

Below Figure shows the circuit construction of 2<sup>nd</sup> Stage Positive Charge Pump.  
Under this circuit, the possible setting range of VGH output voltage is  $(AVDD + 1) V$  to  $(AVDD \times 2 - 1) V$ .  
(When VGH negative current is 0mA)

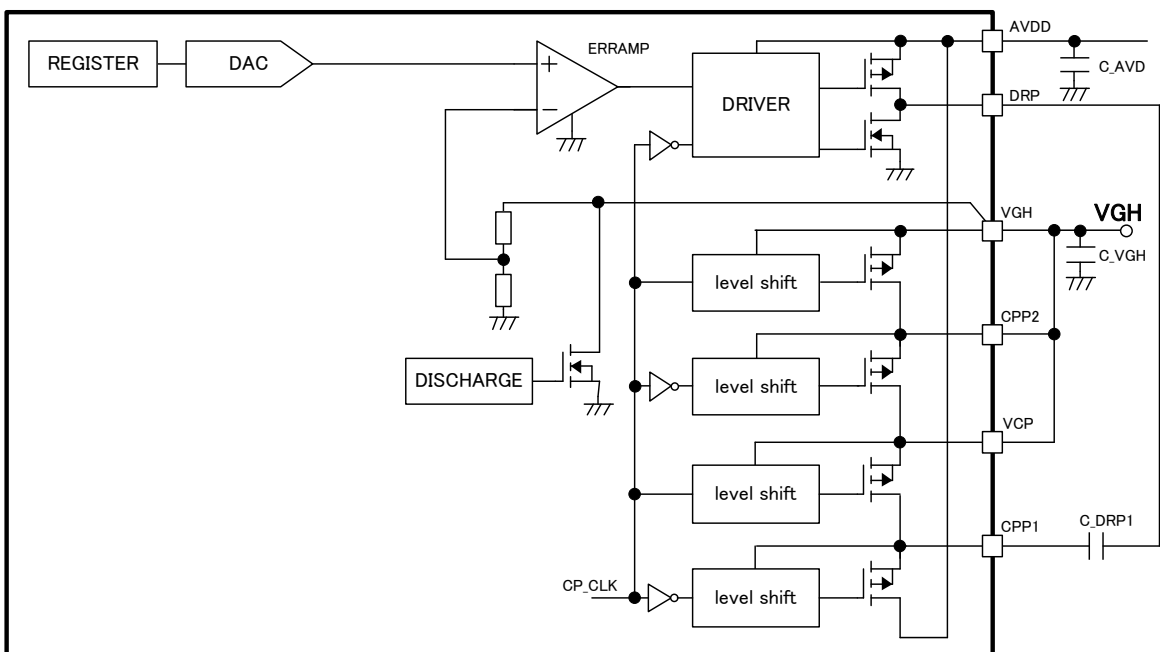


Figure 85. 2<sup>nd</sup> Stage Positive Charge Pump

VGH Block Function - continued

Application Example for VGH (4<sup>th</sup> Stage Positive Charge Pump)

Below Figure shows the circuit construction of 4<sup>th</sup> Stage Positive Charge Pump.  
 Under this circuit, the possible setting range of VGH output voltage is  $(AVDD + 3) V$  to  $(AVDD \times 4 - 3) V$   
 (When VGH negative current is 0mA)

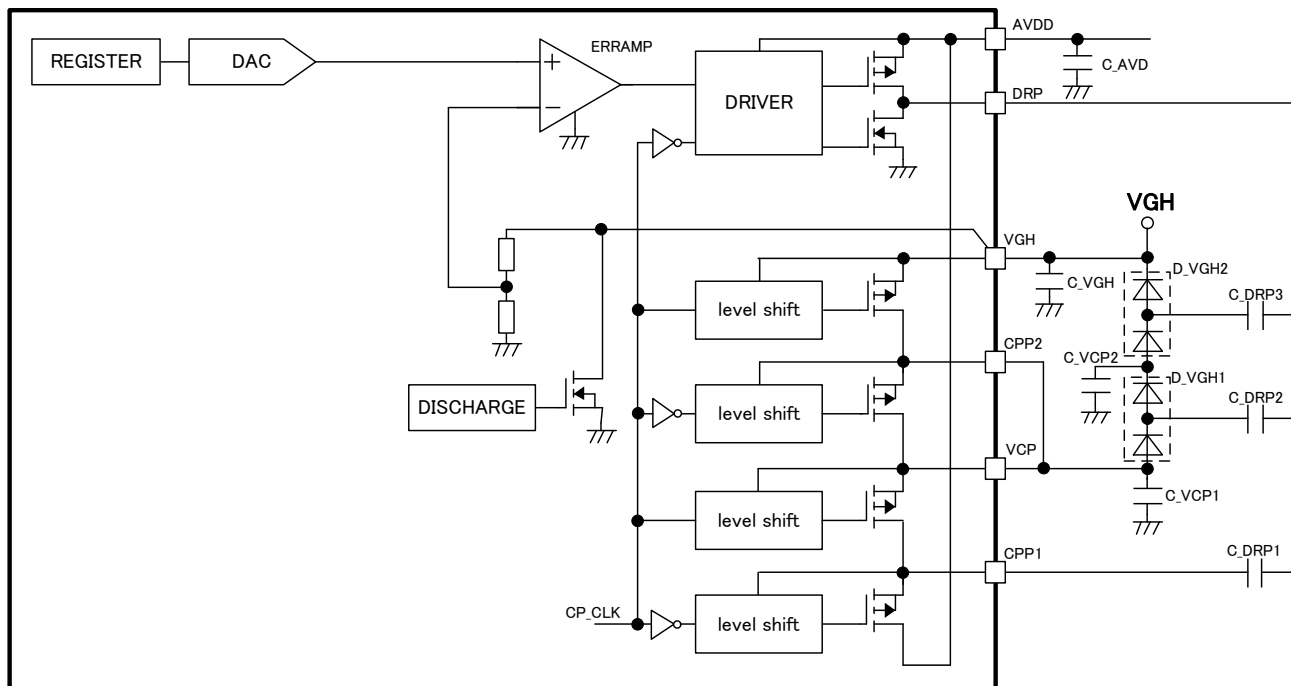


Figure 86. 4<sup>th</sup> Stage Positive Charge Pump

VGL Block Function

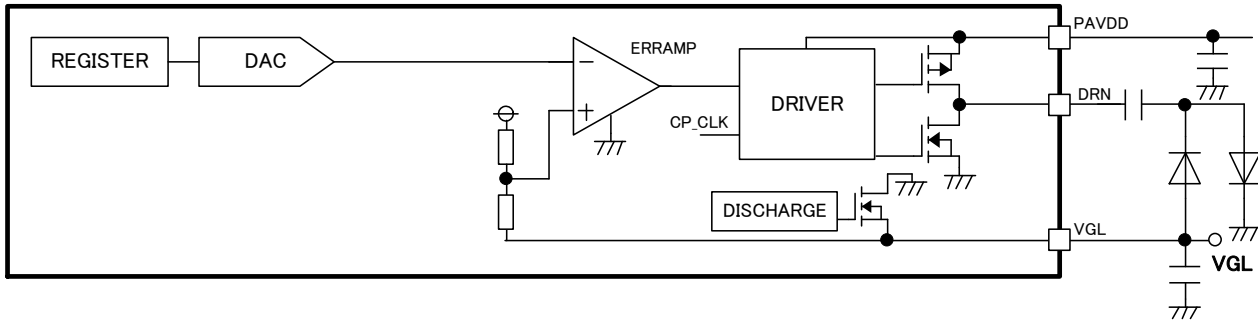


Figure 87. VGL Block Diagram

VGL Block (Negative Charge Pump) can set below functions by EEPROM.

1. VGL Voltage (Register Address 03h [7:0])  
VGL voltage can be set by 0.1V step from -4.0V to -14.0V.
2. DRN Switching Frequency (Register Address 0Ch [5:4])  
Switching frequency can set AVDD frequency x1, x1/2, or x1/4.

Application Example for VGL (1<sup>st</sup> Stage Negative Charge Pump)

Below Figure shows the circuit construction of 1<sup>st</sup> Stage Negative Charge Pump. Under this circuit, the possible setting range of VGL output voltage is -4 V to -(AVDD – 2Vf) V (When VGL positive current is 0mA)

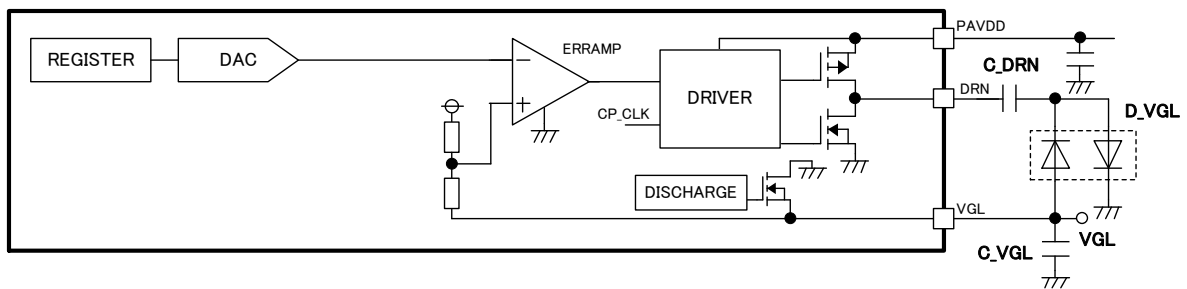


Figure 88. 1<sup>st</sup> Stage Negative Charge Pump

Application Example for VGL (2<sup>nd</sup> Stage Negative Charge Pump)

Below Figure shows the circuit construction of 2<sup>nd</sup> Stage Negative Charge Pump. Under this circuit, the possible setting range of VGL output voltage is -4 V to -(AVDDx2 – 4Vf) V (When VGL positive current is 0mA)

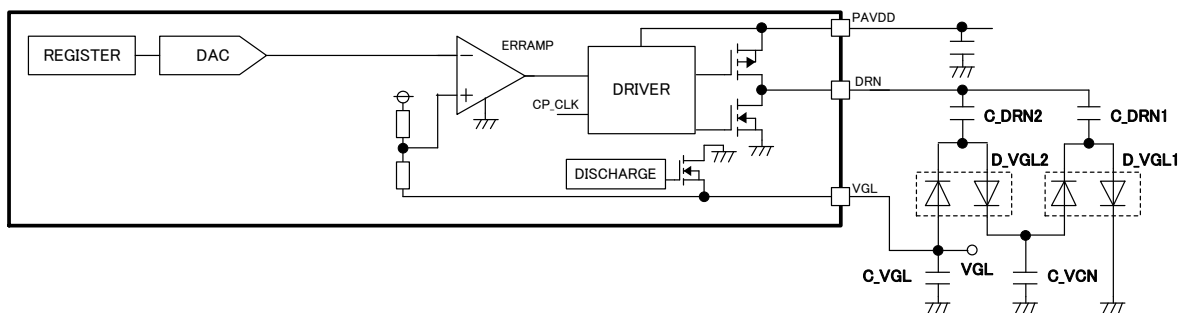


Figure 89. 2<sup>nd</sup> Stage Negative Charge Pump

VCOM Block Function

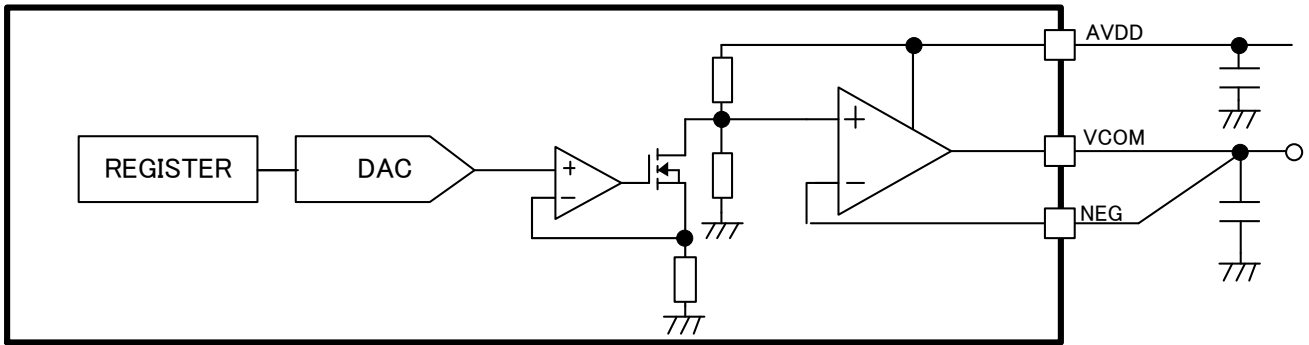
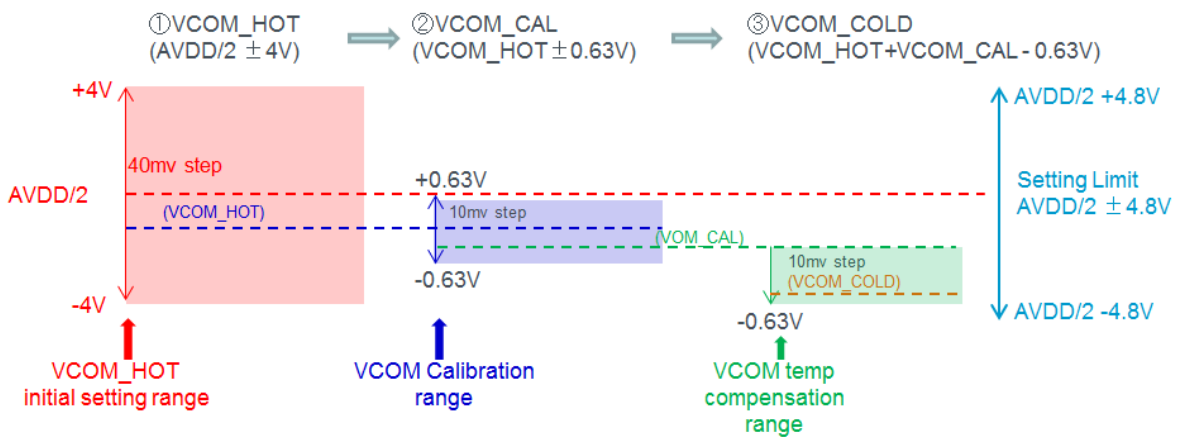


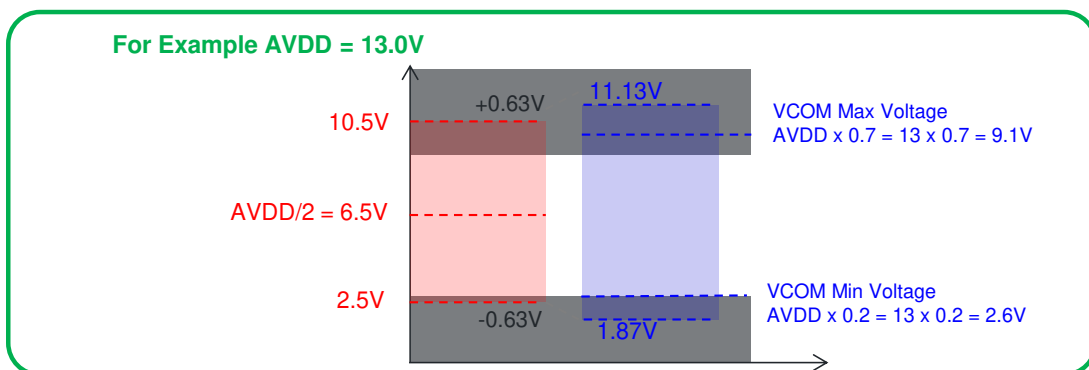
Figure 90. VCOM Block Diagram

VCOM Block (VCOM Calibrator) can set below functions by EEPROM.

1. VCOM (HOT) Voltage (Register Address 04h [7:0])  
VCOM (HOT) voltage can be set by 40mV step from AVDD/2 +/- 0.0V to 4.0V.
2. VCOM (CAL) Voltage (Device Address 1001111x)  
VCOM (CAL) voltage is the function to make minor adjustment of VCOM (HOT) voltage value.  
VCOM (HOT) can be set by 10mV step from +/- 0.0V to 0.63V.  
Refer Page 19, "EEPROM I2C Format for DVR (VCOM calibrator)" for VCOM (CAL) voltage setting.
3. VCOM (COLD) Voltage (Register Address 05h [6:0])  
To set VCOM (COLD) voltage can have the VCOM voltage relates to NTC Pin voltage, when NTC Function is used.  
VCOM (COLD) voltage range can be set by 10mV step from VCOM (CAL)-0V to VCOM (CAL)+0.63V.  
Refer "NTC Block Function" for the detail description of NTC Function.



However, VCOM output voltage setting range is AVDD x0.7 to AVDD x0.2 or AVDD/2+4.8V to AVDD/2-4.8V.



VDD Block Function

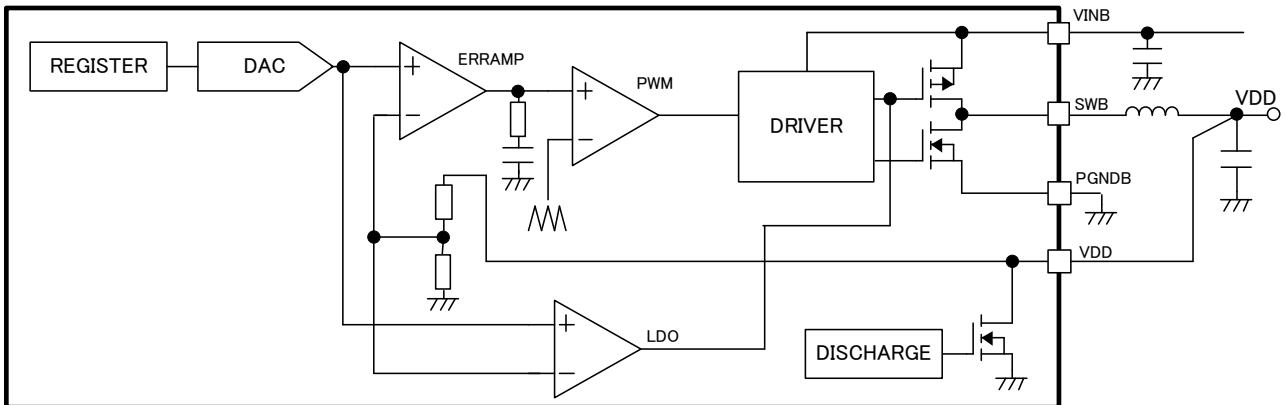


Figure 91. VDD Block Diagram

VDD Block (Buck DC/DC) can set below functions by EEPROM.

1. VDD Voltage (Register Address 06h [5:0])  
VDD voltage can be set by 0.05V step from 0.9V to 3.4V.
2. SWB Switching Frequency (Register Address 0Ch [3:2])  
Switching frequency can be set at 525KHz, 1.05MHz, or 2.1MHz.
3. VDD Phase Adjust (Register Address 06h [7])  
Phase Margin can be adjusted.

0'b : VD\_Phase\_Set1  
1'b : VD\_Phase\_Set2

| VIN[V] | VDD[V]      | VDD Phase Adjust |
|--------|-------------|------------------|
| 5      | 0.9 to 1.25 | 1'b              |
|        | 1.3 to      | 0'b              |
| 3.3    | 0.9 to      | 0'b              |

Set VDD Phase Adjust 1'b when On-duty < 25%.

4. VDD Mode Select (Register Address 06h [6])  
VDD Block can be switched to DC/DC or LDO Mode.  
Since this function switch needs to change the application construction, input writing signal by I2C cannot perform Register writing.  
To write this Register setting, start-up bit(REG0Ch[7]) should be "0".



VDD Block Function – continued

Application Example for VDD (Buck DC/DC)

VDD application can select Buck DC/DC or LDO by “VDD Mode Select” of EEPROM setting. When VDD Mode is selected at “0”, Buck DC/DC operates. Below figure shows example of Buck DC/DC application circuit.

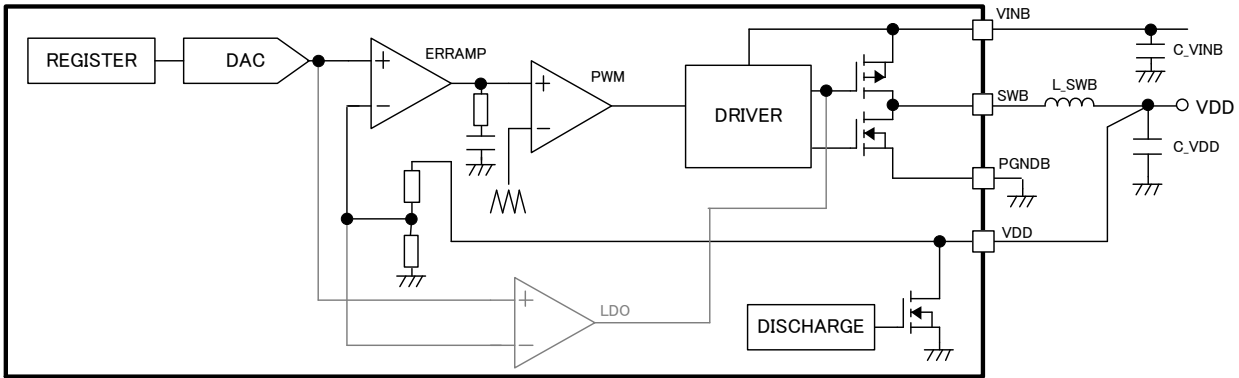


Figure 92. VDD Block Diagram(Buck DC/DC)

Application Example for VDD (LDO)

When VDD Mode is selected at “1”, LDO operates. Below figure shows example of LDO application circuit.

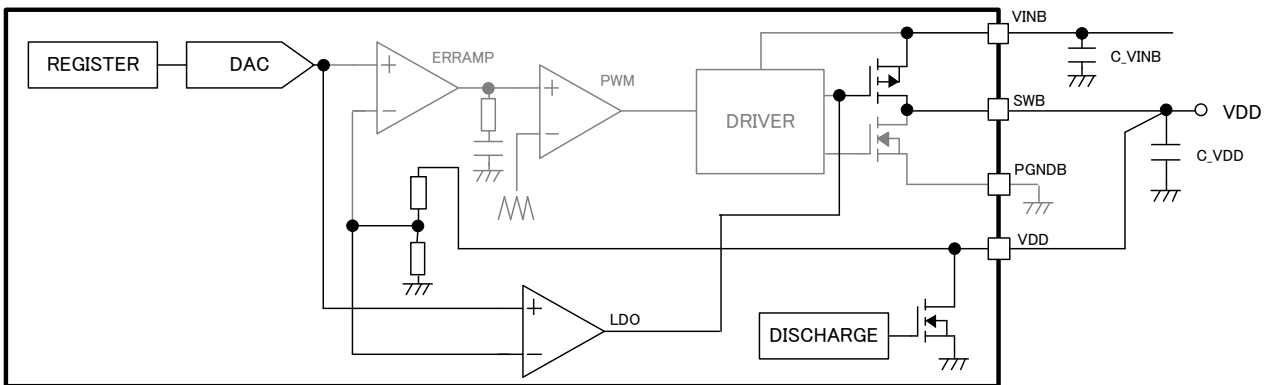


Figure 93. VDD Block Diagram(LDO)

C\_VDD in LDO mode, please use 1.0μF to 10μF.

In addition, when VDD function is not used, please set in VDD LDO mode, and, please connect capacitor more than 1.0μF.

GPM Block Function

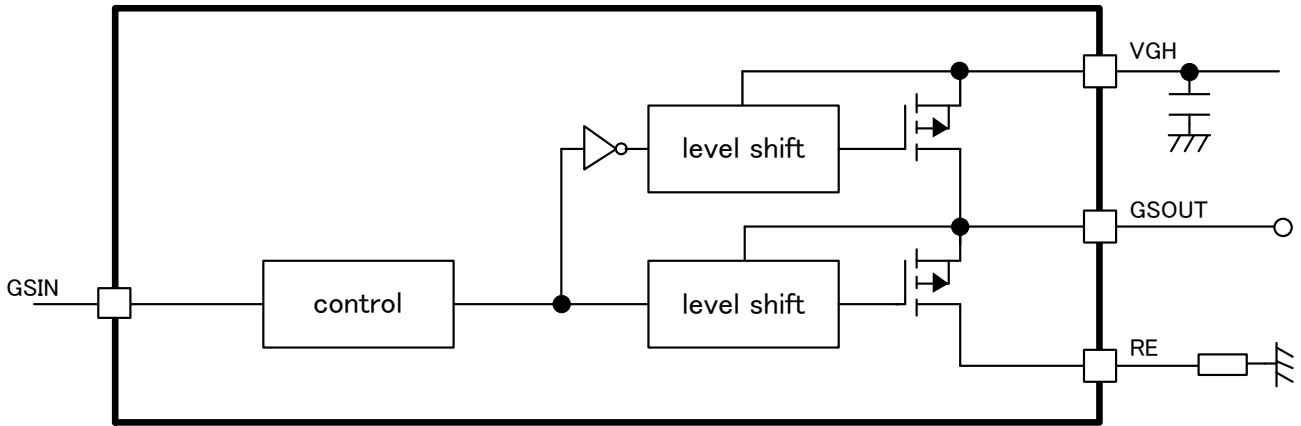


Figure 94. GPM Block Diagram

GPM Block (Gate Pulse Modulation) can set below functions by EEPROM.

- 1. Input Delay Time (Register Address 07h [7:6])  
Falling timing of input signal can be set at 0.1μsec, 0.5μsec, 1.0μsec, or 1.5μsec.

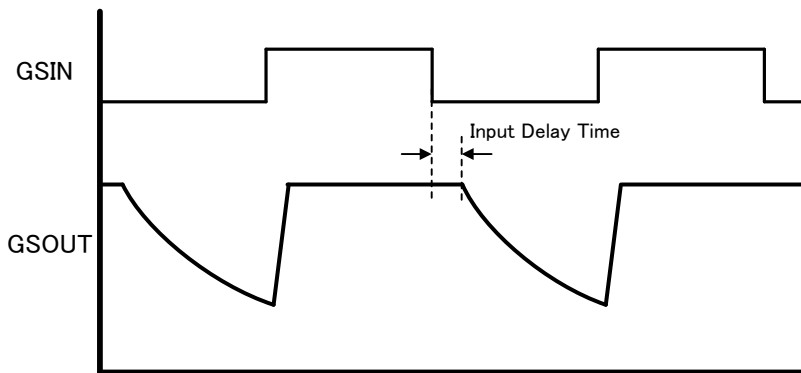


Figure 95. GPM Input Delay Time

Pin connection when GPM is not used

When GPM function is not used, connect GSIN pin to VIN.  
 Connect RE pin to resistance (2.0kohm).  
 GSOUT pin should be OPEN.

RESET Block Function

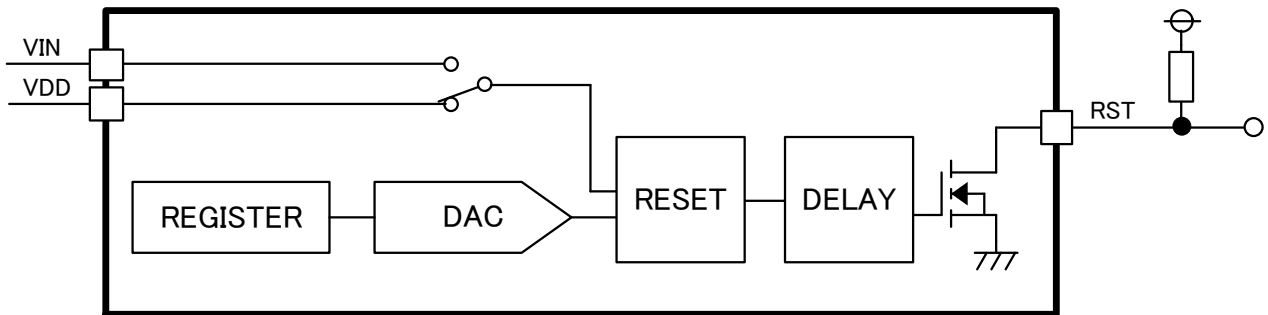


Figure 96. RESET Block Diagram

RESET Block can set below functions by EEPROM.

1. RESET Detect Voltage (Register Address 07h [4:0])  
RESET detection voltage can be set by 0.1V step from 0.6V to 3.3V.
2. RESET Monitor Select (Register Address 07h [5])  
RESET detection pin can select from VDD and VIN.
3. Delay2 Time (Register Address 09h [2:0])  
RESET detection time can be set from 0msec to 40msec.

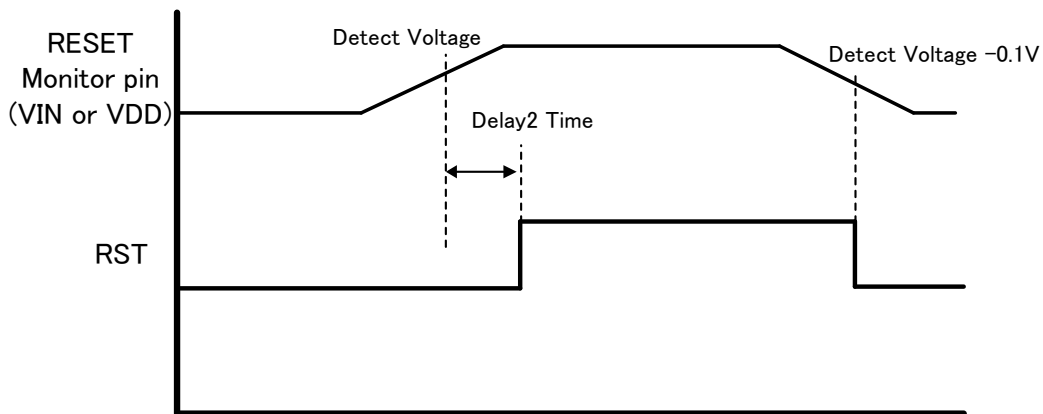


Figure 97. RESET Function

**PG/LDSW Block Function**

PG/LDSW Block can switch PG (Power Good) and LDSW (Load Switch) function by EEPROM.

**Case of PG Function,**

When GPM Block becomes workable, PG pin will change from High to Low to recognize as all boost sequence is completed.

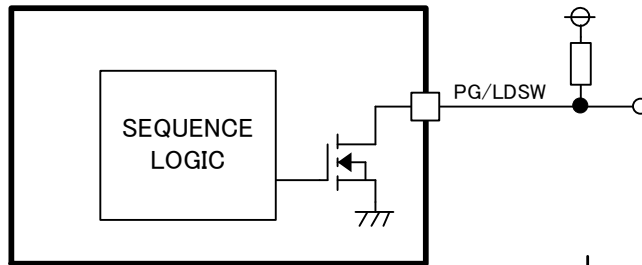
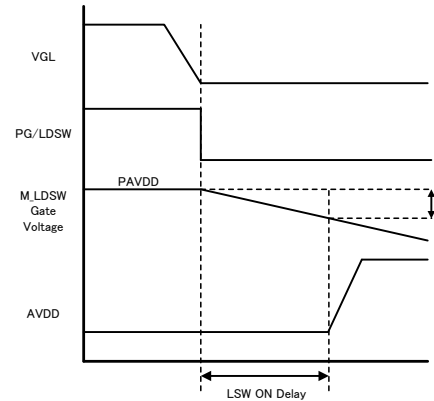


Figure 98. PG/LDSW Block Diagram



**Case of LDSW Function,**

This function is used when VGL voltage output is prior to AVDD voltage output. With below application construction, "Timing Chart 3" sequence can be realized.

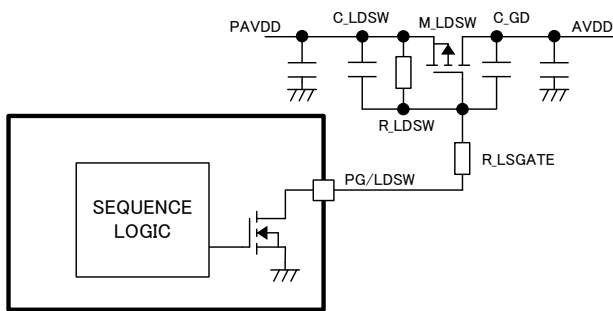


Figure 99. LDSW Function

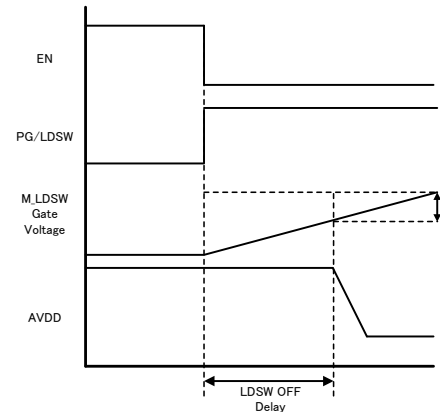


Figure 100. LDSW Delay Time

LDSW on delay can be set by the formula below.

$$LDSW\ ON\ Delay = -C_{LDSW} \times \left( \frac{R_{LSGATE} \times R_{LDSW}}{R_{LSGATE} + R_{LDSW}} \right) \ln \left( 1 - \frac{R_{LSGATE} + R_{LDSW}}{R_{LDSW}} \times \frac{V_{th}}{AVDD} \right) [sec]$$

LDSW off delay can be set by the formula below.

$$LDSW\ OFF\ Delay = -C_{LDSW} \times R_{LDSW} \times \ln \left( \frac{R_{LSGATE} + R_{LDSW}}{R_{LDSW}} \times \frac{V_{th}}{AVDD} \right) [sec]$$

where:

AVDD is AVDD setting voltage.

Vth is M\_LDSW gate threshold voltage

When using the LDSW function, set the delay3 time to be longer than or equal to the sum of the maximum value including the variation of the load switch ON delay time and VGL soft start time. If the delay3 time setting is short, UVP is applied at startup.

NTC Block Function

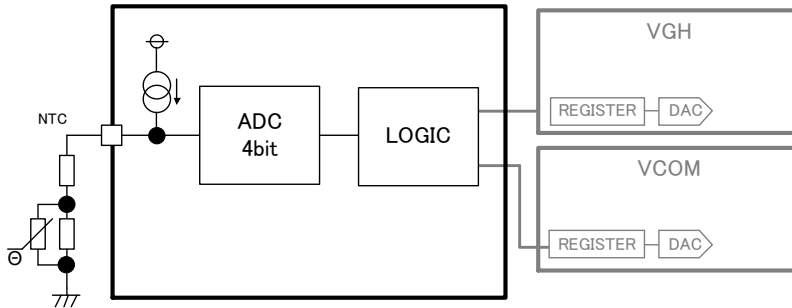


Figure 101. NTC Block Diagram

NTC Block is the function to adjust VGH, VCOM voltage depending on NTC pin voltage.  
 NTC pin will output 40µA (Typ) current.  
 Connecting thermistor element can perform temperature adjustment function.

Below functions can be set by EEPROM.

1. VGH NTC Enable (Register Address 02h [7])  
 VGH Block NTC Function can be changed to Enable or Disable.
2. VCOM NTC Enable (Register Address 05h [7])  
 VCOM Block NTC Function can be changed to Enable or Disable.

Pin connection when NTC is not used.

When NTC function is not used, connect NTC pin to OPEN.

EN Block Function

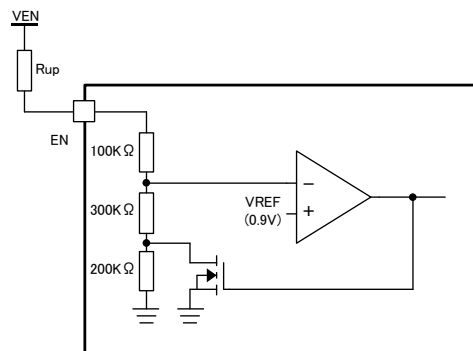


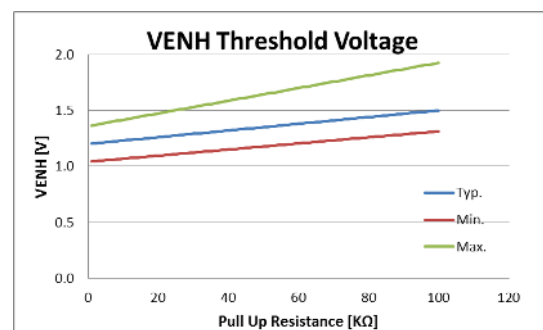
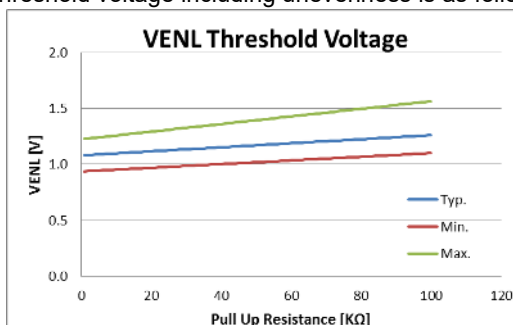
Figure 102. EN Block Diagram

When inserting resistor to EN terminal, EN threshold voltage is decided by resistance division with internal resistor.

Threshold Voltage calculation;

EN threshold voltage high typical (  $V_{ENH}$  ) =  $0.9/300 \times (400 + R_{up})$  [V]  
 EN threshold voltage low typical (  $V_{ENL}$  ) =  $0.9/500 \times (600 + R_{up})$  [V]

The EN threshold voltage including unevenness is as follows;



VGH and VCOM temperature compensation

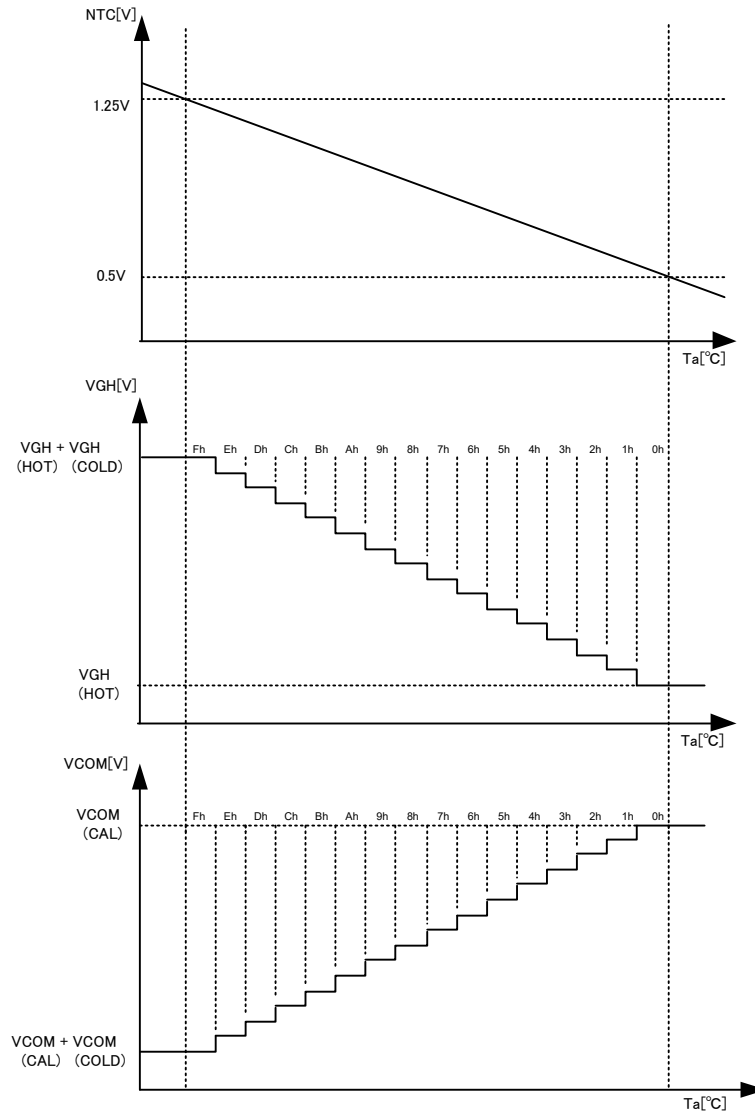


Figure 103. NTC Function

NTC Function can adjust VGH, VCOM voltage depending on NTC voltage (VN<sub>TC</sub>).  
4 bit ADC is used to detect NTC voltage.

When NTC pin voltage VN<sub>TC</sub> ≤ 0.5V, NTC function will judge as HOT setting.  
In this case, VGH and VCOM output voltage can be calculated by below formula.

$$\begin{aligned} VGH &= VGH (HOT) \\ VCOM &= VCOM (CAL) \end{aligned}$$

When NTC pin voltage VN<sub>TC</sub> ≥ 1.25V, NTC function will judge as COLD setting.

$$\begin{aligned} VGH &= VGH (HOT) + \Delta VGH (COLD) \\ VCOM &= VCOM (CAL) - \Delta VCOM (COLD) \end{aligned}$$

When NTC pin voltage is 0.5V < VN<sub>TC</sub> < 1.25V, VGH and VCOM can be estimated by below formula.

$$VGH = \frac{\Delta VGH(COLD)}{15} * \left( ROUNDUP \left( \frac{VN_{TC} - 0.5V}{0.047V} \right) - 1 \right) + VGH(HOT) [V]$$

$$VCOM = VCOM(CAL) - \frac{\Delta VCOM(COLD)}{15} * \left( ROUNDUP \left( \frac{VN_{TC} - 0.5V}{0.047V} \right) - 1 \right) [V]$$

**FAULT Block Function**

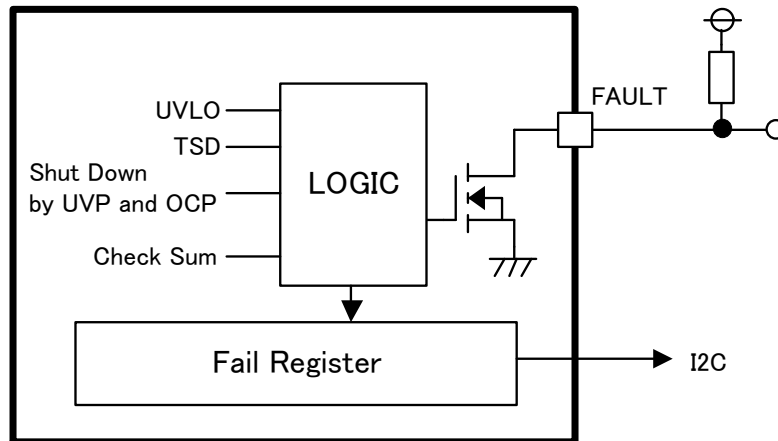


Figure 104. FAULT Block Diagram

FAULT Function is to inform IC situation to outside.  
 When the operation is normal, FAULT pin will be High.  
 When the operation is abnormal, FAULT pin will be Low.

Below are the conditions to have FAULT pin to Low.

- I. Detect UVLO
- II. Start TSD
- III. Shutdown by UVP or OCP
- IV. Check Sum NG

**Fail Register Function**

When FAULT PIN is Low, it is possible to confirm which protection circuit is activating by reading Data from Fail Register.

Fail Register will reflect the protection detected circuit at the moment of FAULT=Low  
 Register Address of Fail Register is 10h.

| Register Address | D7       | D6      | D5      | D4      | D3                    | D2       | D1  | D0              |
|------------------|----------|---------|---------|---------|-----------------------|----------|-----|-----------------|
| 10h              | AVDD UVP | VDD UVP | VGH UVP | VGL UVP | Double Register Error | AVDD OCP | TSD | Check sum Error |

Fail Register does not have EEPROM writing function.  
 When VIN UVLO is detected, the data will be deleted.

Protection function explanation of POWER MANAGEMENT block

- I. UNDER VOLTAGE LOCK OUT (UVLO)  
The BM81810MUV-M has UVLO function for VIN and a circuit miss-operation during in under UVLO voltage operation is prevented. If VIN below UVLO voltage, it shuts down VDD, AVDD, VGH, VGL, GPM, VCOM and RESET.
- II. THERMAL SHUTDOWN (TSD)  
The BM81810MUV-M incorporates a Thermal Shut Down (TSD) function. If IC temperature exceeds 175°C (TYP), it shuts down VDD, AVDD, VGH, VGL, GPM, VCOM and RESET.
- III. UNDER VOLTAGE PROTECTION (UVP)  
This block has Under Voltage Protection (UVP) function for VDD, AVDD, VGH and VGL output.  
When detecting UVP, inner Counter will be activated, and after 5ms passed, it shuts down VDD, AVDD, VGH, VGL, GPM, and VCOM. (It also shuts down RESET when RESET monitors VDD voltage.)
- IV. OVER VOLTAGE PROTECTION (OVP)  
This block has Over Voltage Protection (OVP) function for AVDD output.  
When detecting OVP, output voltage rising is limited by forcing Switching turn off. If output voltage falls, Switching is restarted.
- V. OVER CURRENT PROTECTION (OCP)  
This block has Over Current Protection (OCP) function for VDD and AVDD.  
When detecting OCP, it controls Switching and limits generating over current in FET.

| BLOCK   | Protective Function                        | Working Condition   | Action  | Protective removal                             |
|---------|--|---|---|--|
| VDD     | Over current Protection ( Buck DCDC mode ) | ISWB > 1.0 A (Min)  | Control switching pulse duty to not over current limit  | ISWB < 1.0 A (Min)                             |
|         | Over current Protection ( LDO mode )       | ISWB > 0.3 A (Min)  | Control LDO to not over current limit.  | ISWB < 0.3 A (Min)                             |
|         | Under Voltage Protection                   | Detect : VDD < Target value x 0.8<br>Release : VDD > Target value x 0.9   | IC shutdown<br>if UVP status maintains during 5msec   | IC restart                                     |
| AVDD    | Over Voltage Protection                    | AVDD > (Target value x 1.1)   | Switching STOP  | AVDD < ( Target Value x 1.05 )                 |
|         | Over current Protection                    | ISW > 1.0 A (Min) or 2.0 A (Min)  | Control switching pulse duty to not over current limit<br>IC shutdown<br>if OCP status maintains during 5msec | ISW < 1.0 A (Min) or 2.0 A (Min)<br>IC restart |
|         | Under Voltage Protection                   | Detect : AVDD < Target value x 0.8<br>Release : AVDD > Target value x 0.9 | IC shutdown<br>if UVP status maintains during 5msec   | IC restart                                     |
| VGH     | Under Voltage Protection                   | Detect : VGH < Target value x 0.8<br>Release : VGH > Target value x 0.9   | IC shutdown<br>if UVP status maintains during 5msec   | IC restart                                     |
| VGL     | Under Voltage Protection                   | Detect : VGL > Target value x 0.8<br>Release : VGL < Target value x 0.85  | IC shutdown<br>if UVP status maintains during 5msec   | IC restart                                     |
| General | Under Voltage Lockout                      | VIN < 2.0V (Min)  | IC shutdown   | VIN > 2.55V (Typ)                              |
|         | Thermal shutdown                           | Tj > 175°C (Typ)  | IC shutdown   | Tj < 150°C (Typ)                               |



**Double Register**

BM81810MUV-M can perform various setting by Register.

If these settings are changed without intension, to avoid application abnormal operation, certain specific Register has error detection function.

Below shows the Register with anomaly detection function.

| Register Address | D7                      | D6                | D5                   | D4            | D3                    | D2             | D1             | D0              |
|------------------|-------------------------|-------------------|----------------------|---------------|-----------------------|----------------|----------------|-----------------|
| 00h              | AVDD Output Voltage     |                   |                      |               |                       |                |                |                 |
| 01h              | VGH HOT Output Voltage  |                   |                      |               |                       |                |                |                 |
| 02h              | VGH NTC Enable          | ∇VGH COLD Voltage |                      |               |                       |                |                |                 |
| 03h              | VGL Output Voltage      |                   |                      |               |                       |                |                |                 |
| 04h              | VCOM HOT Output Voltage |                   |                      |               |                       |                |                |                 |
| 05h              | VCOM NTC Enable         | VCOM COLD Voltage |                      |               |                       |                |                |                 |
| 06h              | VDD Phase               | VDD MODE          | VDD Output Voltage   |               |                       |                |                |                 |
| 07h              | GPM Input Delay         |                   | Reset Monitor Select | Reset Voltage |                       |                |                |                 |
| 08h              | Function Select         | Delay1 time       |                      |               |                       | Discharge time |                |                 |
| 09h              | Data Refresh            | Delay3 time       |                      |               | DoubleReg             | Delay2 time    |                |                 |
| 0Ah              | VGH Discharge Enable    | Delay5 time       |                      |               | AR_Time               | Delay4 time    |                |                 |
| 0Bh              | AVDD COMP               | AVDD OCP Select   | AVDD SS Time         |               | AVDD SW Slew Rate     |                | AVDD COIL      |                 |
| 0Ch              | Start-up Bit            | VGH mode select   | VGH/VGL Frequency    |               | VDD Frequency         |                | AVDD Frequency |                 |
| 0Dh              | Check Sum               |                   |                      |               |                       |                |                |                 |
| 10h              | AVDD UVP                | VDD UVP           | VGH UVP              | VGL UVP       | Double Register Error | AVDD OCP       | TSD            | Check sum Error |

 Double Register correspond BIT

**Data Refresh**

Data Refresh is the Function to read Data from EEPROM periodically.

If Register setting is suddenly changed without intension, Data Refresh function can read Data from EEPROM to recover to the normal Data.

Data Refresh performs at certain cycle period.

The time of period can be set by Register at 0.5sec or 1.0sec.

In the case of WPN=Low, Double Register Function and Data Refresh Function can be set by Register as Enable or Disable. Below table shows the function by each combination.

In the case of WPN=High, Double Register Function and Data Refresh Function are Disable.

| WPN  | Data Refresh | Double Register | Data Refresh Operation                 | Double Register Check   |
|------|--------------|-----------------|--|---|
| Low  | 0 : Disable  | 0 : Disable     | Disable                                | Disable<br>(Keep working even logic abnormality happens)  |
| Low  | 0 : Disable  | 1 : Enable      | Disable                                | Enable<br>(First shutdown once logic abnormality detects. After Fault to be low for 1msec, then re-start) |
| Low  | 1 : Enable   | 0 : Disable     | Enable<br>(Data Refresh at set period) | Disable<br>(Keep working even logic abnormality happens)  |
| Low  | 1 : Enable   | 1 : Enable      | Enable<br>(Data Refresh at set period) | Enable<br>(Perform Data Refresh once logic abnormality detects)   |
| High | -            | -               | Disable                                | Disable<br>(Keep working even logic abnormality happens)  |

PCB Layout Guide

GND Wiring Pattern

The high current GND (PGND) should be wired thick. To reduce line impedance, the GND lines must be as short and thick as possible and uses few via. Therefore design at PCB board four layers or above is recommended. (Please use the middle layer as GND shielding and directly connect each GND.) In the case of two layers or less at PCB board designs, please enough confirm with the actual model about the heat and the noise with care to a GND wiring.



Switching-Line Wiring Pattern

The wiring from switching line (SW pin) of DC/DC converter to inductor and diode must be as short and thick as possible. If a wiring is long, ringing by switching increases, and the voltage over the resistance of this IC might be generated. Please note that switching line does not vary PCB layer. Switching line and wiring easily affected by noise such as feedback line must be placed separately. Switching noise spread may cause the lack of operation stability. In case the multi-layer PCB board, please note that a switching line and a line easily affected by noise or the external components are not adjacent between layers. Drawing GND shield line between switching line and these lines easily affected by noise is recommended if these lines are placed close.

Power Supply Voltage Line Wiring Pattern

For power supply voltage (VIN, VINB, VLISO, PAVDD, AVDD, VGH), place smooth capacitor nearby IC pin. Please note that smooth capacitor does not vary PCB layer.

The figure 105 shows an application circuit on the basis of the basic PCB layout pattern guideline mentioned above.

- ◆ Bold line: High current line
- ◆ Blue line(two dots and dashed line): Wiring easily affected by noise
- ◆ Red line (dashed line): Noise source line such as switching line.
- ◆  Place smooth capacitor nearby IC pin
- ◆  D\_SW locates it near SW terminal / PAVDD terminal of BM81810MUV-M, and a current loop of SW terminal ••• SBD ••• PAVDD, please become as short as possible.

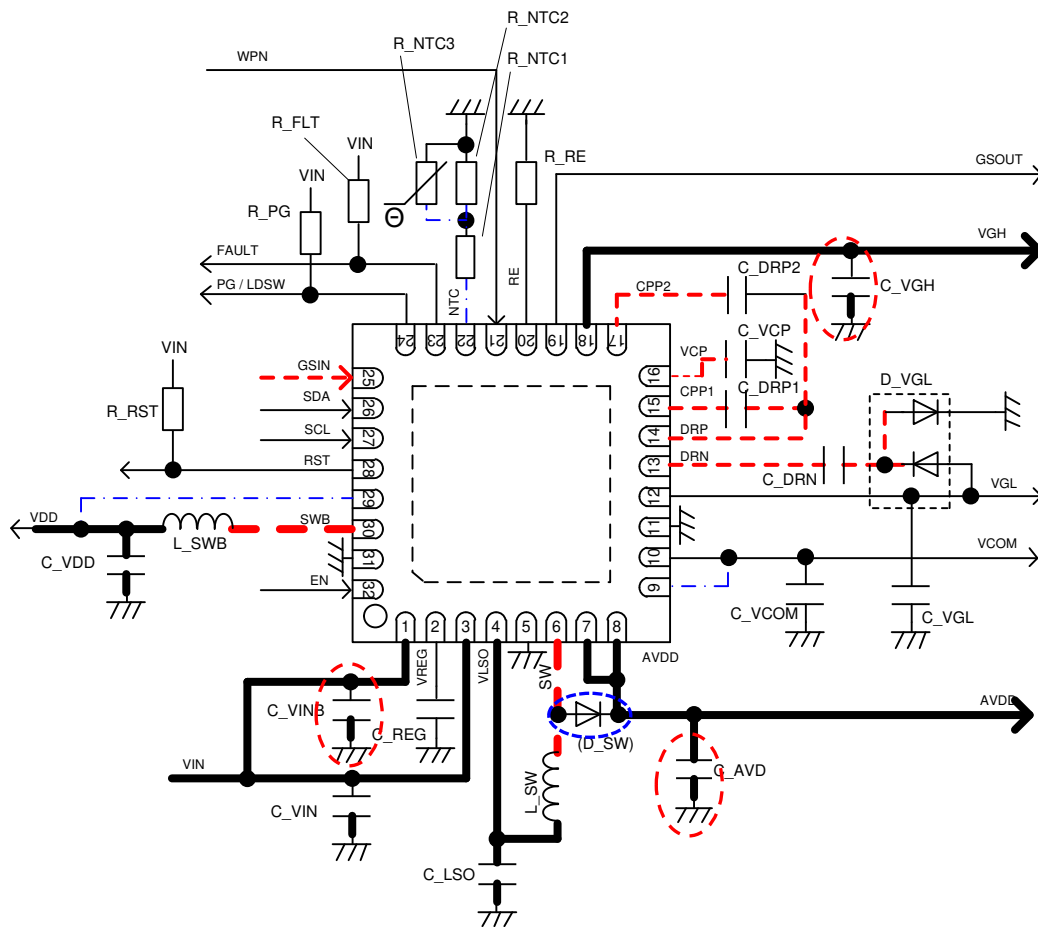


Figure 105. PCB Layout Indications

EMC Layout Guide

Introduce the plan that can design on the PCB as EMC measures.

Measures by the board pattern

- Wire AVDD line briefly thickly. (1)
- Wire the current loop of Boost DC/DC briefly thickly. (2)

Measures by the external component

- Insert a common mode filter or a beads coil in the AVDD line and form the EMC filter. (3)
- Place output capacitor and small capacitor (10pF - 1,000pF) in parallel. (4)
- Insert the snubber circuit in SW pin. (Assumed the efficiency becomes worse) (5)

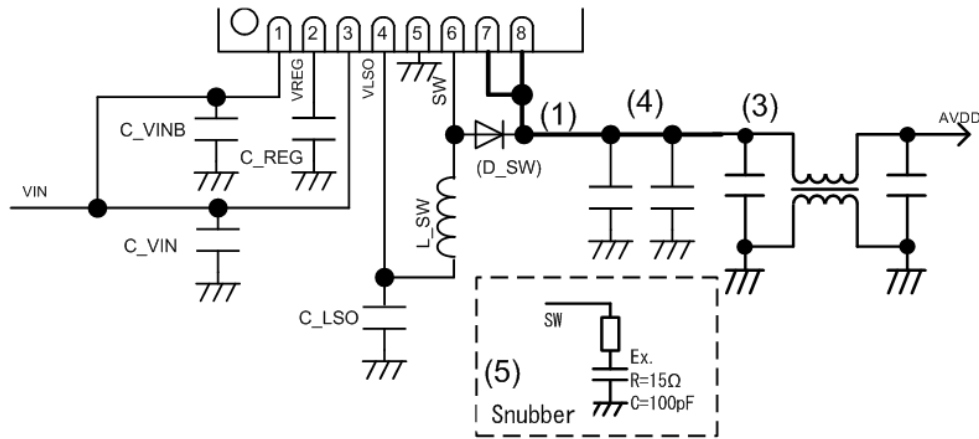


Figure 106. EMI Circuit 1

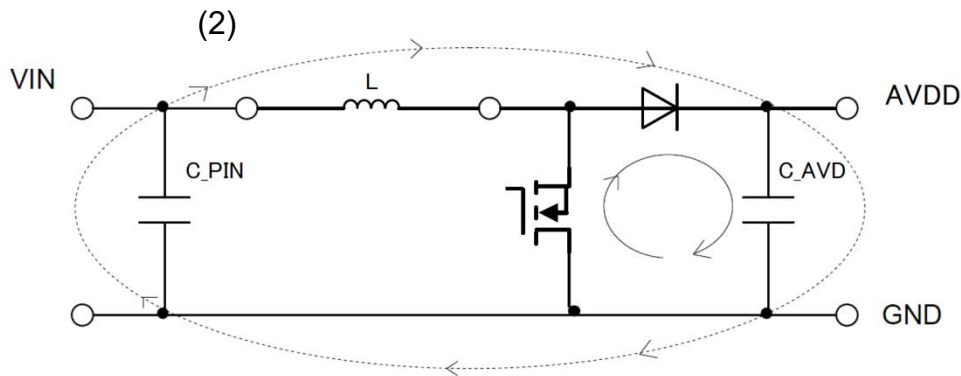
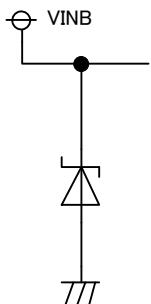
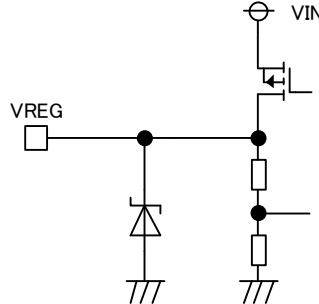
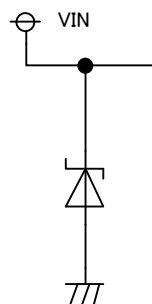
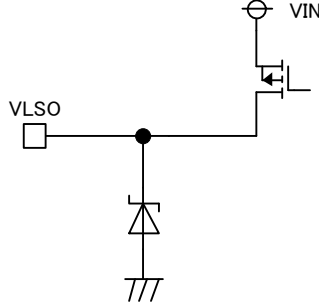
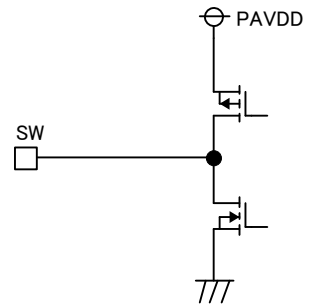
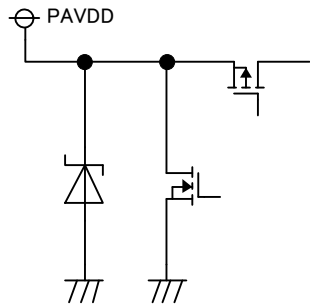
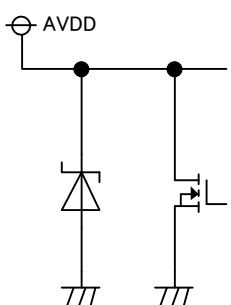
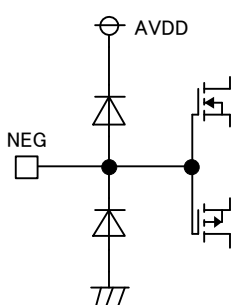
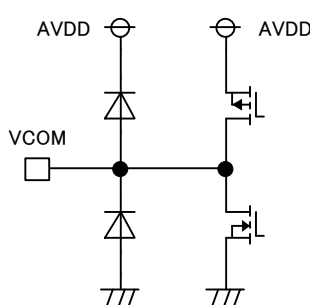
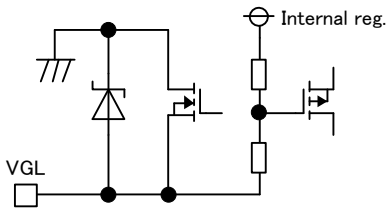
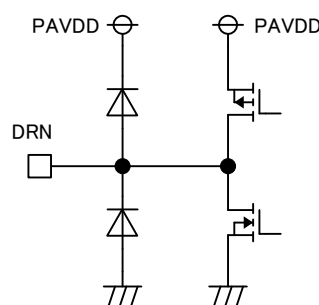
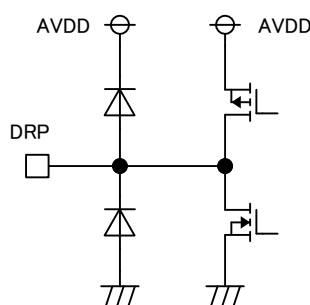


Figure 107. EMI Circuit 2

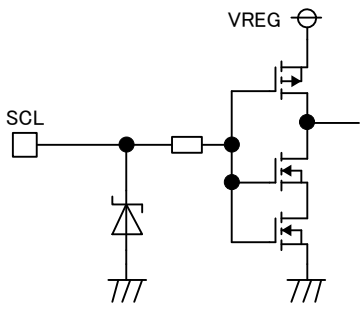
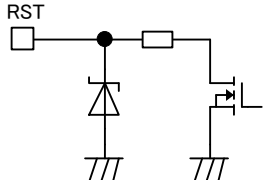
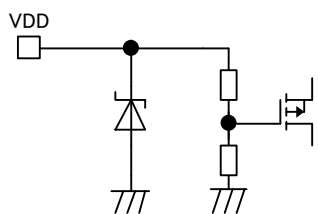
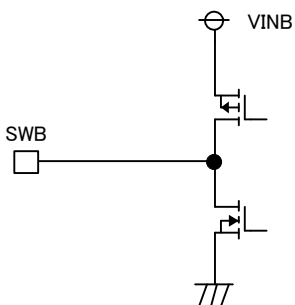
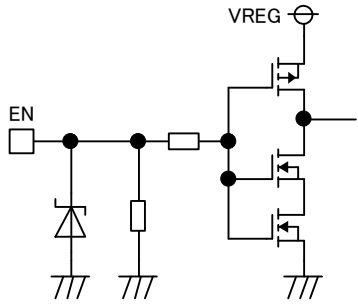
I/O Equivalence Circuit

|  |  |   |
|--|--|---|
| <p>1. VINB</p>    | <p>2. VREG</p>    | <p>3. VIN</p>      |
| <p>4. VLISO</p>  | <p>6. SW</p>     | <p>7. PAVDD</p>   |
| <p>8. AVDD</p>  | <p>9. NEG</p>   | <p>10. VCOM</p>  |
| <p>12. VGL</p>  | <p>13. DRN</p>  | <p>14. DRP</p>   |

I/O Equivalence Circuit - continued

|                    |                  |                  |
|--------------------|------------------|------------------|
| <p>15. CPP1</p>    | <p>16. VCP</p>   | <p>17. CPP2</p>  |
| <p>18. VGH</p>     | <p>19. GSOUT</p> | <p>20. RE</p>    |
| <p>21. WPN</p>     | <p>22. NTC</p>   | <p>23. FAULT</p> |
| <p>24. PG/LDSW</p> | <p>25. GSIN</p>  | <p>26. SDA</p>   |

I/O Equivalence Circuit - continued

|   |  |  |
|---|--|--|
| <p>27. SCL</p>   | <p>28. RST</p>  | <p>29. VDD</p>  |
| <p>30. SWB</p>  | <p>32. EN</p>  |  |

## Operation Notes

### 1. Reverse Connection of Power Supply

Connecting the power supply in reverse polarity can damage the IC. Take precautions against reverse polarity when connecting the power supply, such as mounting an external diode between the power supply and the IC's power supply terminals.

### 2. Power Supply Lines

Design the PCB layout pattern to provide low impedance supply lines. Separate the ground and supply lines of the digital and analog blocks to prevent noise in the ground and supply lines of the digital block from affecting the analog block. Furthermore, connect a capacitor to ground at all power supply pins. Consider the effect of temperature and aging on the capacitance value when using electrolytic capacitors.

### 3. Ground Voltage

Ensure that no pins are at a voltage below that of the ground pin at any time, even during transient condition.

### 4. Ground Wiring Pattern

When using both small-signal and large-current ground traces, the two ground traces should be routed separately but connected to a single ground at the reference point of the application board to avoid fluctuations in the small-signal ground caused by large currents. Also ensure that the ground traces of external components do not cause variations on the ground voltage. The ground lines must be as short and thick as possible to reduce line impedance.

### 5. Thermal Consideration

Should by any chance the power dissipation rating be exceeded the rise in temperature of the chip may result in deterioration of the properties of the chip. In case of exceeding this absolute maximum rating, increase the board size and copper area to prevent exceeding the Pd rating.

### 6. Recommended Operating Conditions

These conditions represent a range within which the expected characteristics of the IC can be approximately obtained. The electrical characteristics are guaranteed under the conditions of each parameter.

### 7. Inrush Current

When power is first supplied to the IC, it is possible that the internal logic may be unstable and inrush current may flow instantaneously due to the internal powering sequence and delays, especially if the IC has more than one power supply. Therefore, give special consideration to power coupling capacitance, power wiring, width of ground wiring, and routing of connections.

### 8. Operation Under Strong Electromagnetic Field

Operating the IC in the presence of a strong electromagnetic field may cause the IC to malfunction.

### 9. 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.

### 10. Inter-pin Short and Mounting Errors

Ensure that the direction and position are correct when mounting the IC on the PCB. Incorrect mounting may result in damaging the IC. Avoid nearby pins being shorted to each other especially to ground, power supply and output pin. Inter-pin shorts could be due to many reasons such as metal particles, water droplets (in very humid environment) and unintentional solder bridge deposited in between pins during assembly to name a few.

### 11. Unused Input Pins

Input pins of an IC are often connected to the gate of a MOS transistor. The gate has extremely high impedance and extremely low capacitance. If left unconnected, the electric field from the outside can easily charge it. The small charge acquired in this way is enough to produce a significant effect on the conduction through the transistor and cause unexpected operation of the IC. So unless otherwise specified, unused input pins should be connected to the power supply or ground line.

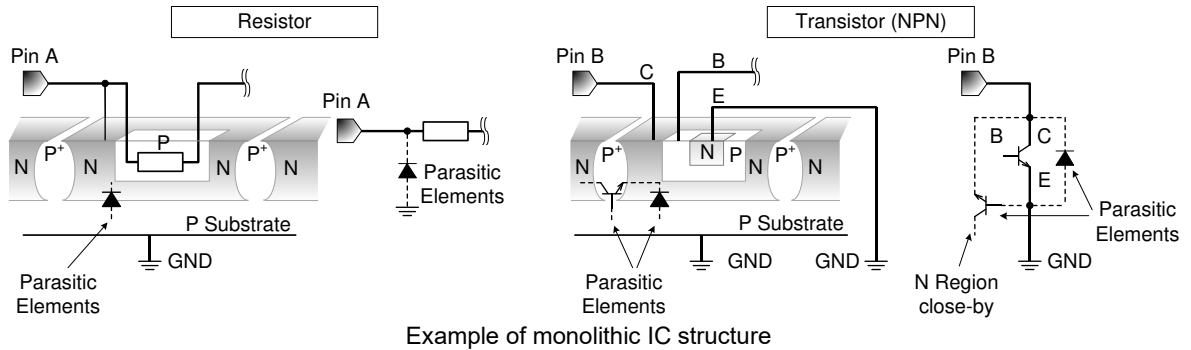
Operational Notes – continued

12. Regarding the Input Pin 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 > Pin A and GND > Pin B, the P-N junction operates as a parasitic diode.  
 When GND > 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.



13. Ceramic Capacitor

When using a ceramic capacitor, determine the dielectric constant considering the change of capacitance with temperature and the decrease in nominal capacitance due to DC bias and others.

14. Area of Safe Operation (ASO)

Operate the IC such that the output voltage, output current, and power dissipation are all within the Area of Safe Operation (ASO).

15. Thermal Shutdown Circuit(TSD)

This IC has a built-in thermal shutdown circuit that prevents heat damage to the IC. Normal operation should always be within the IC's power dissipation rating. If however the rating is exceeded for a continued period, the junction temperature (Tj) will rise which will activate the TSD circuit that will turn OFF all output pins. When the Tj falls below the TSD threshold, the circuits are automatically restored to normal operation.

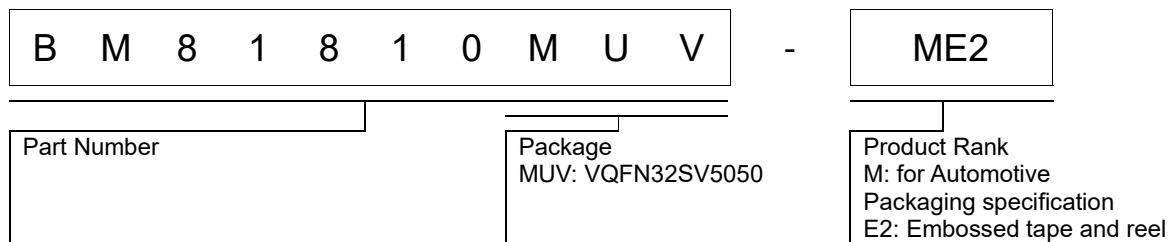
Note that the TSD circuit operates in a situation that exceeds the absolute maximum ratings and therefore, under no circumstances, should the TSD circuit be used in a set design or for any purpose other than protecting the IC from heat damage.

16. Over Current Protection Circuit (OCP)

This IC incorporates an integrated overcurrent protection circuit that is activated when the load is shorted. This protection circuit is effective in preventing damage due to sudden and unexpected incidents. However, the IC should not be used in applications characterized by continuous operation or transitioning of the protection circuit.

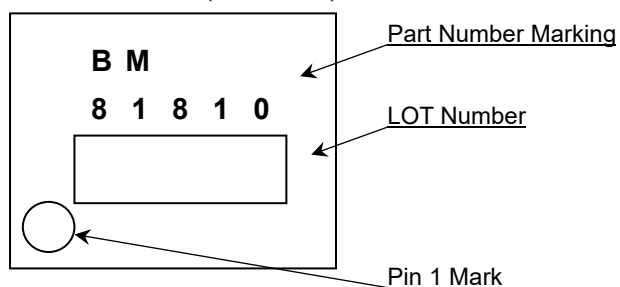


Ordering Information



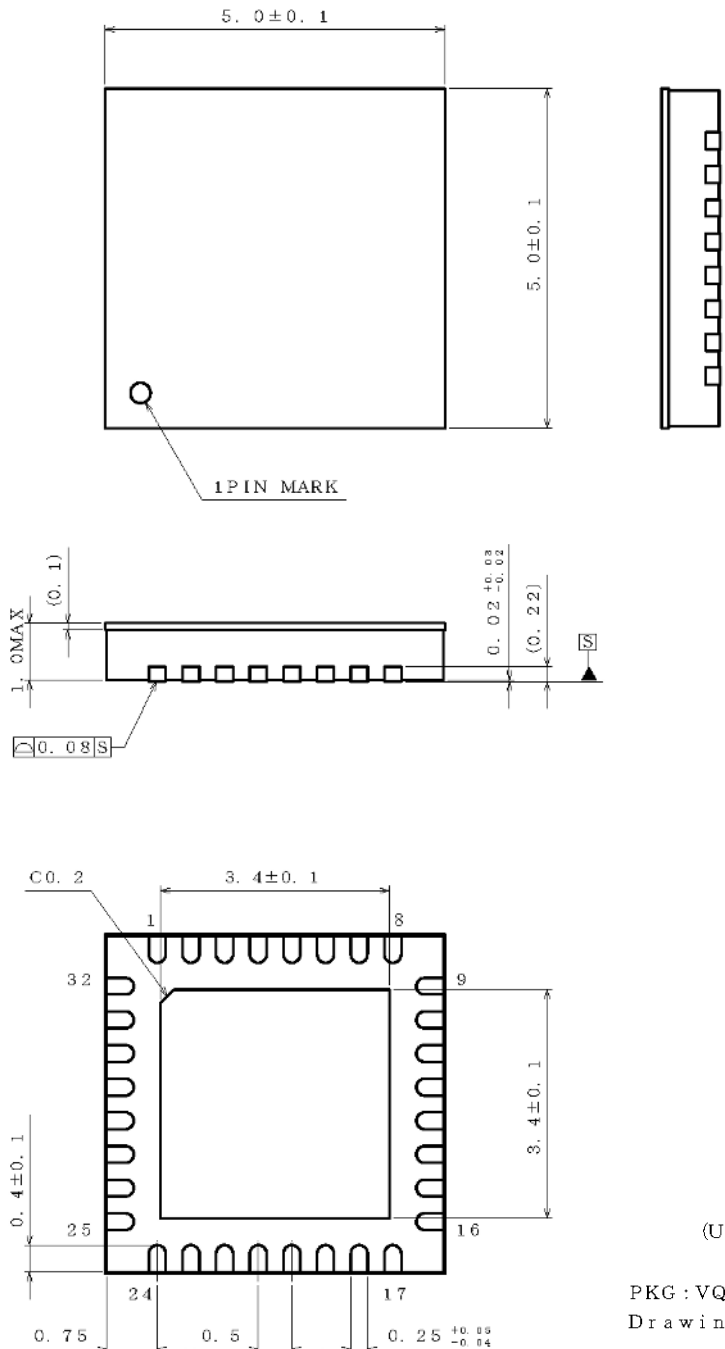
Marking Diagram

VQFN32SV5050(TOP VIEW)



Physical Dimension, Tape and Reel Information

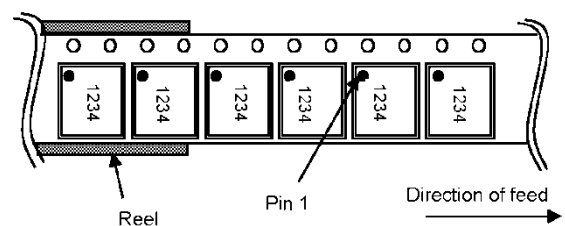
|              |              |
|--------------|--------------|
| Package Name | VQFN32SV5050 |
|--------------|--------------|



(UNIT : mm)  
 PKG : VQFN32SV5050  
 Drawing No. EX385-5001

< Tape and Reel Information >

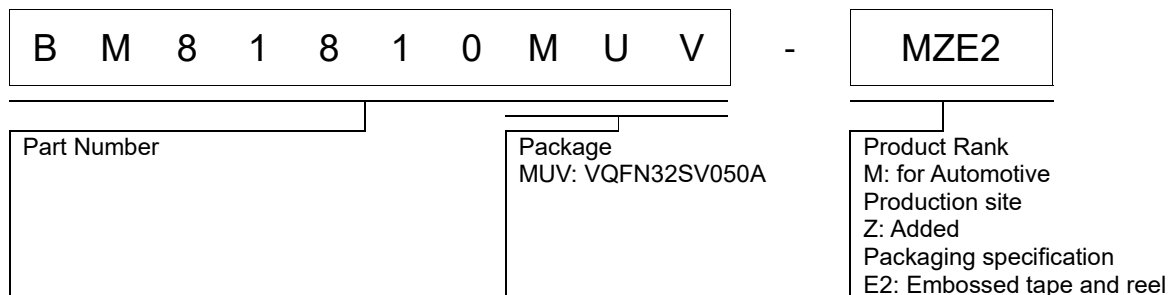
|                   |  |
|-------------------|--|
| Tape              | Embossed carrier tape  |
| Quantity          | 2500pcs  |
| Direction of feed | E2<br>The direction is the pin 1 of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand |



## Revision History

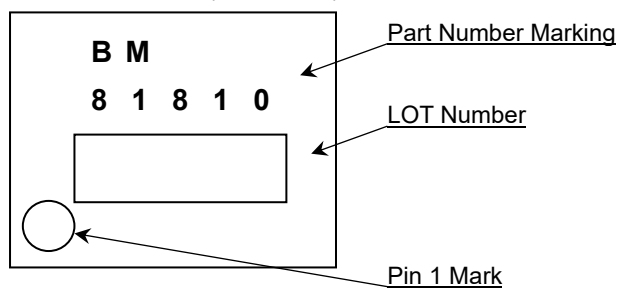
| Date         | Revision | Changes  |
|--------------|----------|--|
| 25.July.2016 | 001      | New Release  |
| 10.Jan.2019  | 002      | AVDD Current Limit (1A setting) Limit Maximum 3.0A -> 2.5A (P.6) |
|              |          | Remove WPN pin from input tolerant. (P.1)                        |
|              |          | Describe the package name in detail. (P.1)                       |
|              |          | Change absolute maximum ratings value of WPN pin. (P.4)          |
|              |          | Add C_GD to application circuit when using LDSW mode.(P.31, P32) |
|              |          | Correct some minor typographical errors.                         |
| 9.Dec.2020   | 003      | Updated packages and part numbers. P.75-2, P.75-3                |

Ordering Information



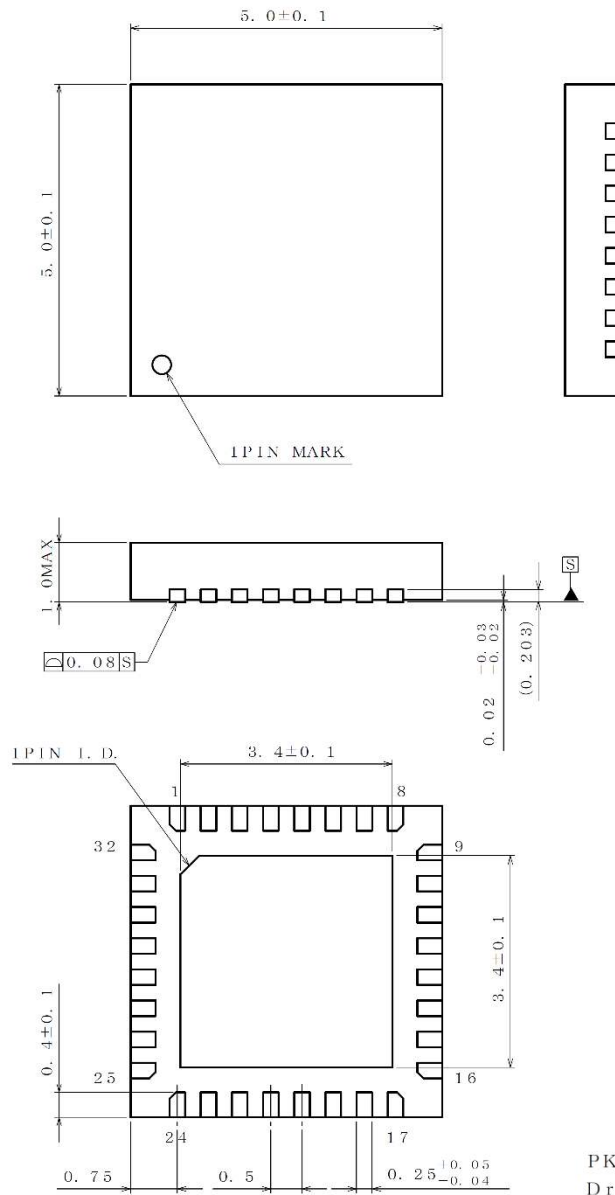
Marking Diagram

VQFN32SV050A(TOP VIEW)



Physical Dimension, Tape and Reel Information

|              |              |
|--------------|--------------|
| Package Name | VQFN32SV050A |
|--------------|--------------|

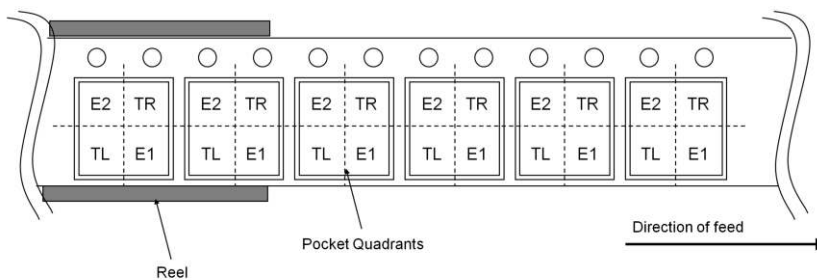


(UNIT : mm)

PKG : VQFN32SV050A  
Drawing No. EX001-0102

< Tape and Reel Information >

|                   |   |
|-------------------|---|
| Tape              | Embossed carrier tape   |
| Quantity          | 2500pcs   |
| Direction of feed | E2<br>The direction is the pin 1 of product is at the upper left<br>when you hold reel on the left hand and you pull out the tape on the right hand |



E2 : PIN1 is placed to the top left corner.      TR : PIN1 is placed to the top right corner.  
TL : PIN1 is placed to the lower left.            E1 : PIN1 is placed to the lower right.

# Notice

## Precaution on using ROHM Products

1. If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment <sup>(Note 1)</sup>, aircraft/spacecraft, nuclear power controllers, 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  |           |

2. 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:
  - [a] Installation of protection circuits or other protective devices to improve system safety
  - [b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure
3. Our Products are not designed 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:
  - [a] Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
  - [b] Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
  - [c] 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>
  - [d] Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
  - [e] Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
  - [f] Sealing or coating our Products with resin or other coating materials
  - [g] Use of our Products without cleaning residue of flux (Exclude cases where no-clean type fluxes is used. However, recommend sufficiently about the residue.); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
  - [h] Use of the Products in places subject to dew condensation
4. The Products are not subject to radiation-proof design.
5. Please verify and confirm characteristics of the final or mounted products in using the Products.
6. 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.
7. De-rate Power Dissipation depending on ambient temperature. When used in sealed area, confirm that it is the use in the range that does not exceed the maximum junction temperature.
8. Confirm that operation temperature is within the specified range described in the product specification.
9. 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

1. When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.
2. 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

A two-dimensional barcode 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.

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