

# T3GE9WBG

## Dual Supply Bus Transceiver for SD Card

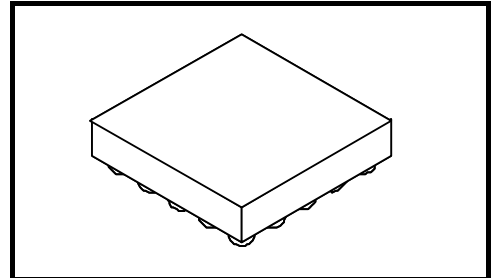
The T3GE9WBG is a dual supply, advanced high-speed CMOS dual supply voltage interface bus transceiver fabricated with silicon gate CMOS technology.

Designed for use as an interface between a 1.8-V bus and a 2.9-V bus in mixed 1.8-V/2.9-V supply systems.

The A-port interfaces with the 1.8-V bus, the B-port with the 2.9-V bus.

The direction of data transmission is determined by the level of the DIR input.

All inputs are equipped with protection circuits against static discharge or transient excess voltage.



Weight: 0.006 g (typ.)

## Features

Bidirectional interface between 1.8-V and 2.9-V buses.

High-speed operation :  $t_{pd} = 8.5 \text{ ns (max)}$  ( $V_{CCA} = 1.8 \pm 0.15 \text{ V}$ ,  $V_{CCB} = 2.9 \pm 0.1 \text{ V}$ )

Output current :  $I_{OHB}/I_{OLB} = \pm 6 \text{ mA (min)}$  ( $V_{CCB} = 2.8 \text{ V}$ )  
 $I_{OHA}/I_{OLA} = \pm 6 \text{ mA (min)}$  ( $V_{CCA} = 1.65 \text{ V}$ )

Regulator output current: 200mA (min)

Integrated EMI filter on B-port

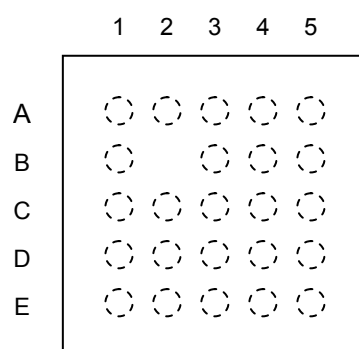
Integrated Pull-up and Pull-down resistors on B-port

Latch-up performance :  $\pm 200 \text{ mA}$

ESD performance : Machine model  $> \pm 200 \text{ V}$   
Human body model  $> \pm 2000 \text{ V}$   
IEC61000-4-2 Level 4 (Contact)  $> \pm 8000 \text{ V}$  (SD card side)

Ultra-small package : WCSP24

## Pin Assignment (top view)



(Top view)

|   | 1      | 2       | 3                | 4                       | 5      |
|---|--------|---------|------------------|-------------------------|--------|
| A | Dat2.h | CMD-dir | Dat0-dir         | V <sub>Batt</sub>       | Dat2-B |
| B | Dat3.h | --      | V <sub>CCA</sub> | V <sub>CCB</sub><br>O/P | Dat3-B |
| C | Clk.h  | Enable  | GND              | GND                     | CLK-B  |
| D | Dat0.h | CMD.h   | CD               | CMD-B                   | Dat0-B |
| E | Dat1.h | Clk-f   | Dat123-dir       | WP                      | Dat1-B |

## Truth Table

| Input | Outputs |       |
|-------|---------|-------|
| Clk.h | Clk-f   | CLK-B |
| L     | L       | L     |
| H     | H       | H     |

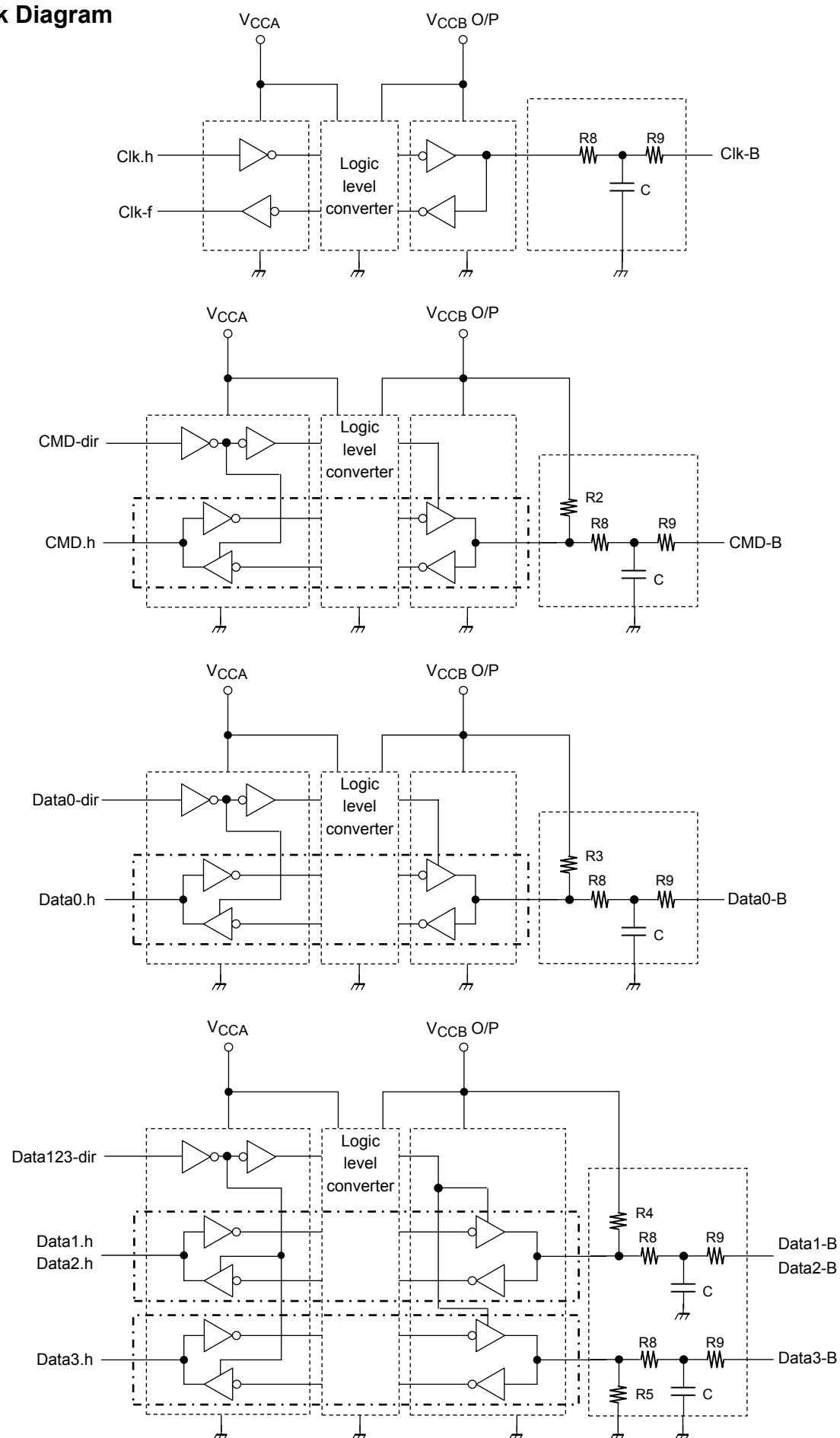
| Inputs  | Function |        | Outputs       |
|---------|----------|--------|---------------|
| CMD-dir | CMD.h    | CMD-B  |               |
| L       | Output   | Input  | CMD.h = CMD-B |
| H       | Input    | Output | CMD-B = CMD.h |

| Inputs   | Function |        | Outputs         |
|----------|----------|--------|-----------------|
| Dat0-dir | Dat0.h   | Dat0-B |                 |
| L        | Output   | Input  | Dat0.h = Dat0-B |
| H        | Input    | Output | Dat0-B = Dat0.h |

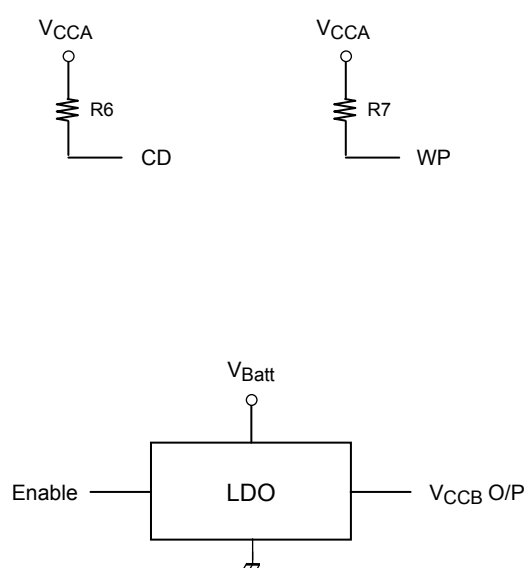
| Inputs     | Function           |                    | Outputs         |
|------------|--------------------|--------------------|-----------------|
| Dat123-dir | Dat1.h –<br>Dat3.h | Dat1-B –<br>Dat3-B |                 |
| L          | Output             | Input              | Datn.h = Datn-B |
| H          | Input              | Output             | Datn-B = Datn.h |

| Input  | Output    |
|--------|-----------|
| Enable | Regulator |
| L      | OFF       |
| H      | ON        |

## Block Diagram



## Block Diagram



| Symbol | Value (typ) |
|--------|-------------|
| R3, R4 | 70kΩ        |
| R2     | 15kΩ        |
| R5     | 470kΩ       |
| R6, R7 | 100kΩ       |
| R8     | 5Ω          |
| R9     | 35Ω         |
| C      | 35pF        |

## Absolute Maximum Ratings (Note 1)

| Characteristics                                   |            | Symbol            | Rating                                  | Unit |
|---------------------------------------------------|------------|-------------------|-----------------------------------------|------|
| Power supply voltage                              |            | V <sub>CCA</sub>  | −0.5 to 3.0                             | V    |
|                                                   |            | V <sub>Batt</sub> | 5.5                                     |      |
| DC input voltage                                  | DIR, Clk.h | V <sub>IN</sub>   | −0.5 to V <sub>CCA</sub> + 0.5          | V    |
|                                                   | Enable     |                   | −0.5 to 5.5                             |      |
| DC bus I/O voltage                                |            | V <sub>I/OA</sub> | −0.5 to V <sub>CCA</sub> + 0.5 (Note 2) | V    |
|                                                   |            | V <sub>I/OB</sub> | −0.5 to V <sub>CCB</sub> + 0.5 (Note 2) |      |
| Input diode current                               | DIR, Clk.h | I <sub>IK</sub>   | ±25                                     | mA   |
|                                                   | Enable     |                   | −25                                     |      |
| Output diode current                              |            | I <sub>I/OK</sub> | ±25 (Note 3)                            | mA   |
| DC output current                                 |            | I <sub>OUTA</sub> | ±25                                     | mA   |
|                                                   |            | I <sub>OUTB</sub> | ±25                                     |      |
| DC V <sub>CC</sub> /ground current per supply pin |            | I <sub>CCA</sub>  | ±50                                     | mA   |
| Power dissipation                                 |            | P <sub>D</sub>    | 400                                     | mW   |
| Storage temperature                               |            | T <sub>stg</sub>  | −55 to 150                              | °C   |

Note 1: Exceeding any of the absolute maximum ratings, even briefly, lead to deterioration in IC performance or even destruction.

Note 2: High or Low stats. I<sub>OUT</sub> absolute maximum rating must be observed.

Note 3: V<sub>OUT</sub> < GND, V<sub>OUT</sub> > V<sub>CC</sub>

**Operating Range (Note 1)**

| Characteristics          |            | Symbol     | Rating                      | Unit |
|--------------------------|------------|------------|-----------------------------|------|
| Power supply voltage     |            | $V_{CCA}$  | 1.65 to 1.95                | V    |
|                          |            | $V_{Batt}$ | 3.2 to 5.0                  |      |
| Input voltage            | DIR, Clk.h | $V_{IN}$   | 0 to $V_{CCA}$              | V    |
|                          | Enable     |            | 0 to 5.0                    |      |
| Bus I/O voltage          |            | $V_{I/OA}$ | 0 to $V_{CCA}$ (Note 2)     | V    |
|                          |            | $V_{I/OB}$ | 0 to $V_{CCB}$ O/P (Note 2) |      |
| Output current           |            | $I_{OUTA}$ | $\pm 6$ (Note 3)            | mA   |
|                          |            | $I_{OUTB}$ | $\pm 6$ (Note 4)            |      |
| Operating temperature    |            | $T_{opr}$  | -30 to 85                   | °C   |
| Input rise and fall time |            | dt/dv      | 0 to 10 (Note 5)            | ns/V |

Note 1: The operating range is required to ensure the normal operation of the device. Unused inputs and bus inputs must be tied to either VCC or GND. Please connect both bus inputs and the bus outputs with VCC or GND when the I/O of the bus terminal changes by the function. In this case, please note that the output is not short-circuited.

Note 2: High or low state

Note 3:  $V_{CCA} = 1.65$  to  $1.95$  V

Note 4:  $V_{CCB} = 2.8$  to  $3.0$  V,  $V_{CCB}$  is supplied from the built-in LDO.

Note 5:  $V_{CCA} = 1.65$  V,  $V_{CCB} = 2.8$  V

**Electrical Characteristics**
**DC Characteristics ( $1.65\text{ V} \leq V_{CCA} \leq 1.95\text{ V}$ ,  $2.8\text{ V} \leq V_{CCB} \leq 3.0\text{ V}$ )**

| Characteristics          | Symbol           | Test Condition                                                                                                                                           |                            | V <sub>CCA</sub> (V) | V <sub>CCB</sub> (V) | Ta = −30 to 85°C       |                        | Unit |
|--------------------------|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|----------------------|----------------------|------------------------|------------------------|------|
|                          |                  |                                                                                                                                                          |                            |                      |                      | Min                    | Max                    |      |
| H-level input voltage    | V <sub>IHA</sub> | DIR, An (Note 1)                                                                                                                                         |                            | 1.65 to 1.95         | 2.8 to 3.0           | V <sub>CCA</sub> ×0.65 | —                      | V    |
|                          | V <sub>IHB</sub> | Bn (Note 1)                                                                                                                                              |                            | 1.65 to 1.95         | 2.8 to 3.0           | 2.0                    | —                      |      |
| L-level input voltage    | V <sub>ILA</sub> | DIR, An (Note 1)                                                                                                                                         |                            | 1.65 to 1.95         | 2.8 to 3.0           | —                      | V <sub>CCA</sub> ×0.35 | V    |
|                          | V <sub>ILB</sub> | Bn (Note 1)                                                                                                                                              |                            | 1.65 to 1.95         | 2.8 to 3.0           | —                      | 0.8                    |      |
| H-level output voltage   | V <sub>OHA</sub> | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                                                                                                     | I <sub>OHA</sub> = −100μA  | 1.65 to 1.95         | 2.8 to 3.0           | V <sub>CCA</sub> − 0.2 | —                      | V    |
|                          |                  |                                                                                                                                                          | I <sub>OHA</sub> = −6 mA   | 1.65                 | 2.8 to 3.0           | 1.15                   | —                      |      |
|                          | V <sub>OHB</sub> |                                                                                                                                                          | I <sub>OHB</sub> = −100 μA | 1.65 to 1.95         | 2.8 to 3.0           | V <sub>CCB</sub> − 0.2 | —                      |      |
|                          |                  |                                                                                                                                                          | I <sub>OHB</sub> = −6 mA   | 1.65 to 1.95         | 2.8                  | 2.2                    | —                      |      |
| L-level output voltage   | V <sub>OLA</sub> | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                                                                                                     | I <sub>OLA</sub> = 100 μA  | 1.65 to 1.95         | 2.8 to 3.0           | —                      | 0.2                    | V    |
|                          |                  |                                                                                                                                                          | I <sub>OLA</sub> = 6 mA    | 1.65                 | 2.8 to 3.0           | —                      | 0.3                    |      |
|                          | V <sub>OLB</sub> |                                                                                                                                                          | I <sub>OLB</sub> = 100 μA  | 1.65 to 1.95         | 2.8 to 3.0           | —                      | 0.2                    |      |
|                          |                  |                                                                                                                                                          | I <sub>OLB</sub> = 6 mA    | 1.65 to 1.95         | 2.8                  | —                      | 0.4                    |      |
| Input leakage current    | I <sub>IA</sub>  | V <sub>INA</sub> = V <sub>CCA</sub> or GND<br>DIR = HIGH<br>V <sub>CD</sub> = V <sub>WP</sub> = V <sub>CCA</sub>                                         |                            | 1.65 to 1.95         | 2.8 to 3.0           | —                      | ±5.0                   | μA   |
|                          | I <sub>IB</sub>  | V <sub>CMD-B</sub> , DAT0, DAT1, DAT2 = V <sub>CCA</sub><br>V <sub>DAT3</sub> = GND<br>DIR = LOW<br>V <sub>CD</sub> = V <sub>WP</sub> = V <sub>CCA</sub> |                            | 1.65 to 1.95         | 2.8 to 3.0           | —                      | ±5.0                   |      |
| Quiescent supply current | I <sub>CCA</sub> | V <sub>INA</sub> = V <sub>CCA</sub> or GND<br>DIR = HIGH<br>V <sub>CD</sub> = V <sub>WP</sub> = V <sub>CCA</sub>                                         |                            | 1.65 to 1.95         | 2.8 to 3.0           | —                      | 20                     | μA   |

Note 1: An is a host side signal. Bn is a card side signal.

Note:  $V_{CCB}$  is supplied from the built-in LDO.

## AC Characteristics (Ta = -30 to 85°C, Input: tr = tf = 2.0 ns)

VCCA = 1.8 ± 0.15 V, VCCB = 2.9 ± 0.1 V

| Characteristics                           | Symbol                                 | Test Condition     | Min | Typ. | Max | Unit |
|-------------------------------------------|----------------------------------------|--------------------|-----|------|-----|------|
| Propagation delay time<br>(Bn → An)       | t <sub>pLH</sub><br>t <sub>pHL</sub>   | Figure 1, Figure 2 | 1.0 | —    | 8.5 | ns   |
| Propagation delay time<br>(An → Bn)       | t <sub>pLH</sub><br>t <sub>pHL</sub>   | Figure 1, Figure 2 | 1.0 | —    | 8.5 | ns   |
| Propagation delay time<br>(Clk.h → Clk-f) | t <sub>pLH</sub><br>t <sub>pHL</sub>   | Figure 1, Figure 2 | 1.0 | —    | 14  | ns   |
| Output Transition Time<br>(An)            | t <sub>TLH</sub><br>t <sub>THL</sub>   | Figure 1, Figure 2 | —   | 1.5  | —   | ns   |
| Output Transition Time<br>(Bn)            | t <sub>TLH</sub><br>t <sub>THL</sub>   | Figure 1, Figure 2 | —   | 1.5  | —   | ns   |
| Output to output skew                     | t <sub>osLH</sub><br>t <sub>osHL</sub> | (Note 1)           | —   | —    | 0.5 | ns   |

Note 1: Parameter guaranteed by design. (t<sub>osLH</sub> = |t<sub>pLHm</sub> - t<sub>pLHn</sub>|, t<sub>osHL</sub> = |t<sub>pHLm</sub> - t<sub>pHLn</sub>|)

Note: An is a host side signal. Bn is a card side signal.

VCCB is supplied from the built-in LDO.

## Dynamic Switching Characteristics (Ta = 25°C, Input: tr = tf = 2.0 ns, CL = 15 pF)

| Characteristics                     |       | Symbol | Test Condition                   | VCCA (V) | VCCB (V) | Typ.  | Unit |
|-------------------------------------|-------|--------|----------------------------------|----------|----------|-------|------|
| Quiet output maximum<br>dynamic VOL | A → B | VOLP   | VIH = VCC, VIL = 0 V<br>(Note 2) | 1.8      | 2.9      | 0.35  | V    |
|                                     | B → A |        |                                  | 1.8      | 2.9      | 0.25  |      |
| Quiet output minimum<br>dynamic VOL | A → B | VOLV   | VIH = VCC, VIL = 0 V<br>(Note 2) | 1.8      | 2.9      | -0.35 | V    |
|                                     | B → A |        |                                  | 1.8      | 2.9      | -0.25 |      |
| Quiet output maximum<br>dynamic VOH | A → B | VOHP   | VIH = VCC, VIL = 0 V<br>(Note 2) | 1.8      | 2.9      | 3.25  | V    |
|                                     | B → A |        |                                  | 1.8      | 2.9      | 2.05  |      |
| Quiet output minimum<br>dynamic VOH | A → B | VOHV   | VIH = VCC, VIL = 0 V<br>(Note 2) | 1.8      | 2.9      | 2.55  | V    |
|                                     | B → A |        |                                  | 1.8      | 2.9      | 1.55  |      |

Note 2: Parameter guaranteed by design.

Note: An is a host side signal. Bn is a card side signal.

## Capacitive Characteristics (Ta = 25°C)

| Characteristics                           |      | Symbol | Test Circuit      | VCCA (V) | VCCB (V) | Typ. | Unit |
|-------------------------------------------|------|--------|-------------------|----------|----------|------|------|
| Power dissipation capacitance<br>(Note 3) | CPDA |        | A → B (DIR = "H") | 1.8      | 2.9      | 24   | pF   |
|                                           |      |        | B → A (DIR = "L") | 1.8      | 2.9      | 22   |      |
|                                           | CPDB |        | A → B (DIR = "H") | 1.8      | 2.9      | 76   |      |
|                                           |      |        | B → A (DIR = "L") | 1.8      | 2.9      | 28   |      |

Note 3: CPD is defined as the value of the internal equivalent capacitance which is calculated from the operating current consumption without load.

Average operating current can be obtained by the equation:

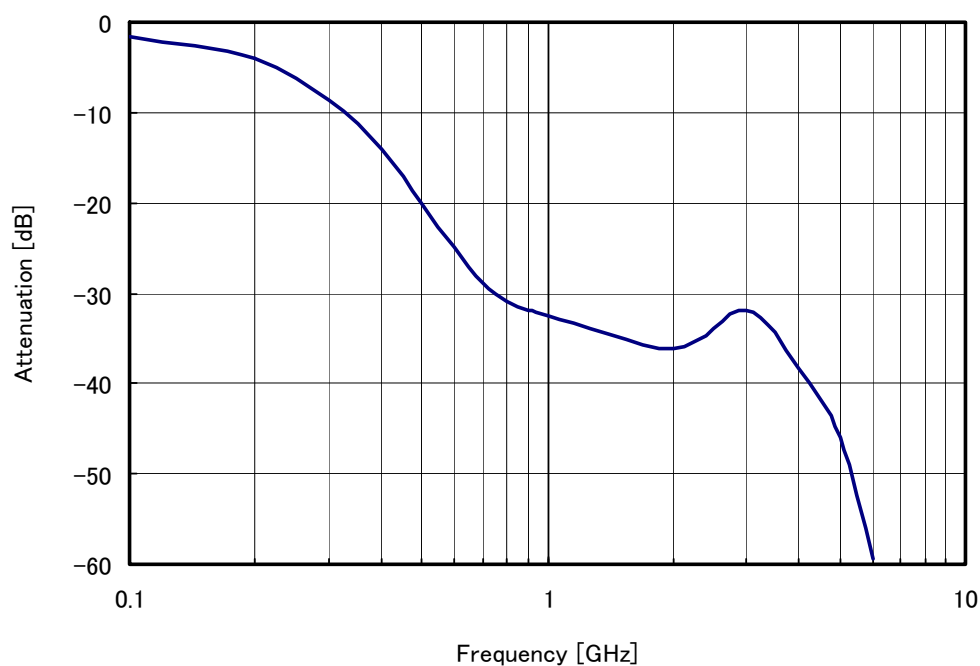
$$I_{CC(opr)} = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC}/6 \text{ (per bit)}$$

## Regulator Section

**Electrical Characteristics (unless otherwise specified,  $V_{IN} = V_{OUT} + 1\text{ V}$ ,  $I_{OUT} = 1\text{ mA}$ ,  $C_{IN} = 0.1\text{ }\mu\text{F}$ ,  $C_{OUT} = 2.2\text{ }\mu\text{F}$ ,  $T_j = 25^\circ\text{C}$ )**

| Characteristics         | Symbol                | Test Condition                                                                                                                                        | Min | Typ. | Max      | Unit                  |
|-------------------------|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|-----|------|----------|-----------------------|
| Input voltage           | $V_{IN}$              | —                                                                                                                                                     | 3.2 | —    | 5.0      | V                     |
| Output voltage          | $V_{CCB}\text{ O/P}$  | —                                                                                                                                                     | 2.8 | 2.9  | 3.0      | V                     |
| Line regulation         | Reg·line              | $V_{OUT} + 0.5\text{ V} \leq V_{IN} \leq 5.0\text{ V}$ ,<br>$I_{OUT} = 1\text{ mA}$                                                                   | —   | 3    | 15       | mV                    |
| Load regulation         | Reg·load              | $1\text{ mA} \leq I_{OUT} \leq 200\text{ mA}$                                                                                                         | —   | —    | 150      | mV                    |
| Quiescent current       | $I_{B1}$              | $I_{OUT} = 0\text{ mA}$                                                                                                                               | —   | 40   | 80       | $\mu\text{A}$         |
|                         | $I_{B2}$              | $I_{OUT} = 100\text{ mA}$                                                                                                                             | —   | 45   | 85       |                       |
| Stand-by current        | $I_B\text{ (OFF)}$    | $V_{CT} = 0\text{ V}$                                                                                                                                 | —   | 0.1  | 1.0      | $\mu\text{A}$         |
| Output noise voltage    | $V_{NO}$              | $V_{IN} = V_{OUT} + 1\text{ V}$ , $I_{OUT} = 10\text{ mA}$ ,<br>$10\text{ Hz} \leq f \leq 100\text{ kHz}$ ,<br>$T_a = 25^\circ\text{C}$               | —   | 140  | —        | $\mu\text{V}_{rms}$   |
| Temperature coefficient | $T_{CVO}$             | $-40^\circ\text{C} \leq T_{opr} \leq 85^\circ\text{C}$                                                                                                | —   | 100  | —        | ppm/ $^\circ\text{C}$ |
| Ripple rejection        | R.R.                  | $V_{IN} = V_{OUT} + 1\text{ V}$ , $I_{OUT} = 10\text{ mA}$ ,<br>$f = 1\text{ kHz}$ , $V_{Ripple} = 500\text{ mV}_{p-p}$ ,<br>$T_a = 25^\circ\text{C}$ | —   | 40   | —        | dB                    |
| Control voltage (ON)    | $V_{CT}\text{ (ON)}$  | —                                                                                                                                                     | 1.5 | —    | $V_{IN}$ | V                     |
| Control voltage (OFF)   | $V_{CT}\text{ (OFF)}$ | —                                                                                                                                                     | 0   | —    | 0.25     | V                     |
| Control current (ON)    | $I_{CT}\text{ (ON)}$  | $V_{CT} = 1.5\text{ V}$                                                                                                                               | —   | —    | 0.1      | $\mu\text{A}$         |
| Control current (OFF)   | $I_{CT}\text{ (OFF)}$ | $V_{CT} = 0\text{ V}$                                                                                                                                 | —   | —    | 0.1      | $\mu\text{A}$         |
| Peak output current     | $I_{outpeak}$         | —                                                                                                                                                     | 200 | —    | —        | mA                    |

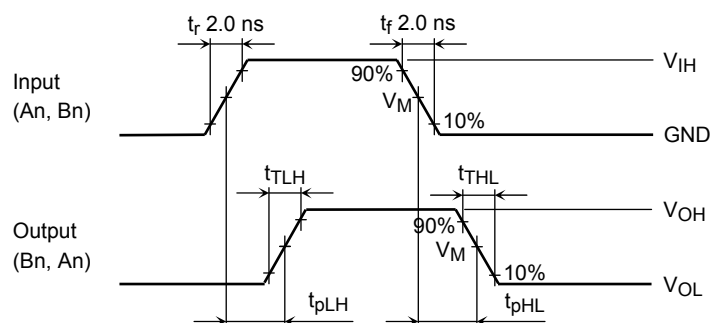
## EMI Filter Response (Typical Performance)





| Symbol         | V <sub>CC</sub> (output) |              |
|----------------|--------------------------|--------------|
|                | 2.9 ± 0.1 V              | 1.8 ± 0.18 V |
| R <sub>L</sub> | 2 kΩ                     | 2 kΩ         |
| C <sub>L</sub> | 15 pF                    | 15 pF        |

## AC Waveform

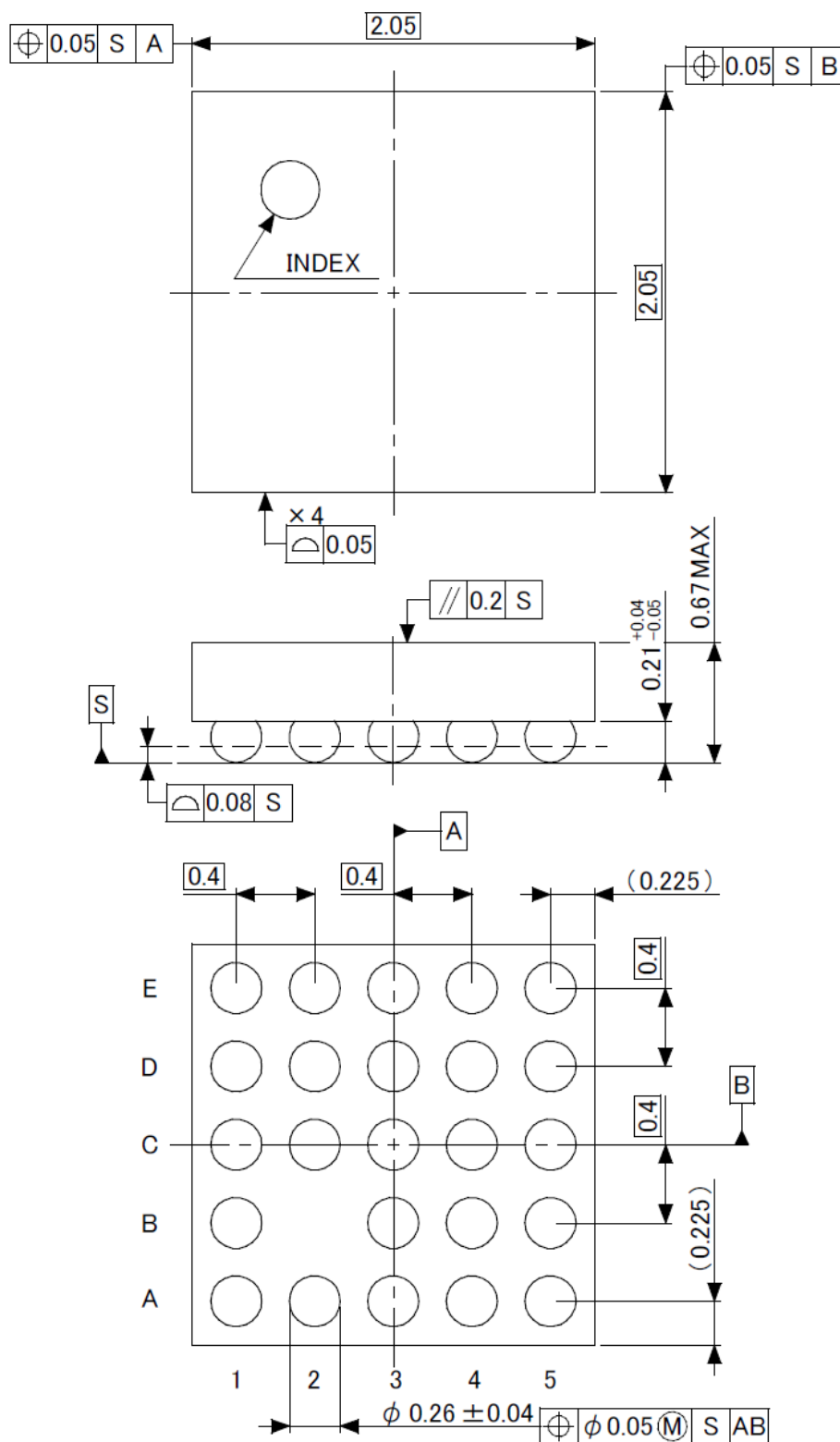


**Figure 2**  $t_{pLH}$ ,  $t_{pHL}$ ,  $t_{TLH}$ ,  $t_{THL}$

| Symbol          | V <sub>CC</sub>    |                    |
|-----------------|--------------------|--------------------|
|                 | 2.9 ± 0.1 V        | 1.8 ± 0.18 V       |
| V <sub>IH</sub> | V <sub>CC</sub>    | V <sub>CC</sub>    |
| V <sub>M</sub>  | V <sub>CC</sub> /2 | V <sub>CC</sub> /2 |

S-WFBGA24-0303-0.40A02

Unit: mm



The resin used in this product includes no flame retardants.

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