# *ASSP   Image Processing*

## BIPOLAR

# D/A Converter (1-ch, 8-bit, 60 MSPS)

# MB40768H

## ■ DESCRIPTION

The MB40768H is a low-power and high-speed 8-bit D/A converter.

The digital input is TTL compatible and the analog output voltage is 3 to 5 V. Maximum conversion speed is 60 MHz. The internal reference voltage provided has two types of resistor division scheme and band-gap reference scheme; the external reference voltage may also be used.

The MB40768H is suitable for high-definition TV or VCR application.

## ■ FEATURES

- Resolution: 8 bits
- Conversion characteristics:  Maximum conversion rate: 60 MSPS [min.]
                                                     Linearity error: ±0.2 % [max.]
- I/O: Digital input voltage: TTL level
          Analog output voltage: $2V_{P-P}$ (3 to 5 V)
- Reference voltage:     $V_{ROUT1}$: Resistor division circuit ($0.6 \times V_{CCA}$)
                                      $V_{ROUT2}$: Band-gap reference circuit ($V_{CCA} - 2$ V)
- Power supply voltage: +5 V single power supply
- Power consumption:  160 mW [typical value for the analog output voltage of 2 $V_{P-P}$]
                                    120 mW [typical value for the analog output voltage of 1 $V_{P-P}$]

## ■ PACKAGES

18-pin Plastic DIP

20-pin Plastic SOP

(DIP-18P-M02)

(FPT-20P-M01)

## ■ PIN ASSIGNMENTS



(Top view)

(MSB) D$_1$ — 1 ... 18 — CLK
D$_2$ — 2 ... 17 — V$_{CCD}$
D$_3$ — 3 ... 16 — V$_{CCA}$
D$_4$ — 4 ... 15 — A.OUT
D$_5$ — 5 ... 14 — V$_{ROUT2}$
D$_6$ — 6 ... 13 — V$_{RIN}$
D$_7$ — 7 ... 12 — V$_{ROUT1}$
(LSB) D$_8$ — 8 ... 11 — COMP
D.GND — 9 ... 10 — A.GND

(DIP-18P-M02)

(Top view)

(MSB) D$_1$ — 1 ... 20 — CLK
D$_2$ — 2 ... 19 — V$_{CCD}$
D$_3$ — 3 ... 18 — V$_{CCA}$
D$_4$ — 4 ... 17 — A.OUT
D$_5$ — 5 ... 16 — V$_{ROUT2}$
D$_6$ — 6 ... 15 — V$_{RIN}$
D$_7$ — 7 ... 14 — V$_{ROUT1}$
(LSB) D$_8$ — 8 ... 13 — N.C.
N.C. — 9 ... 12 — COMP
D.GND — 10 ... 11 — A.GND
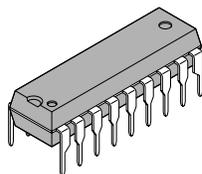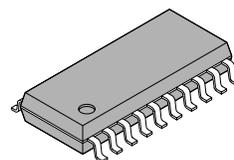
(FPT-20P-M01)
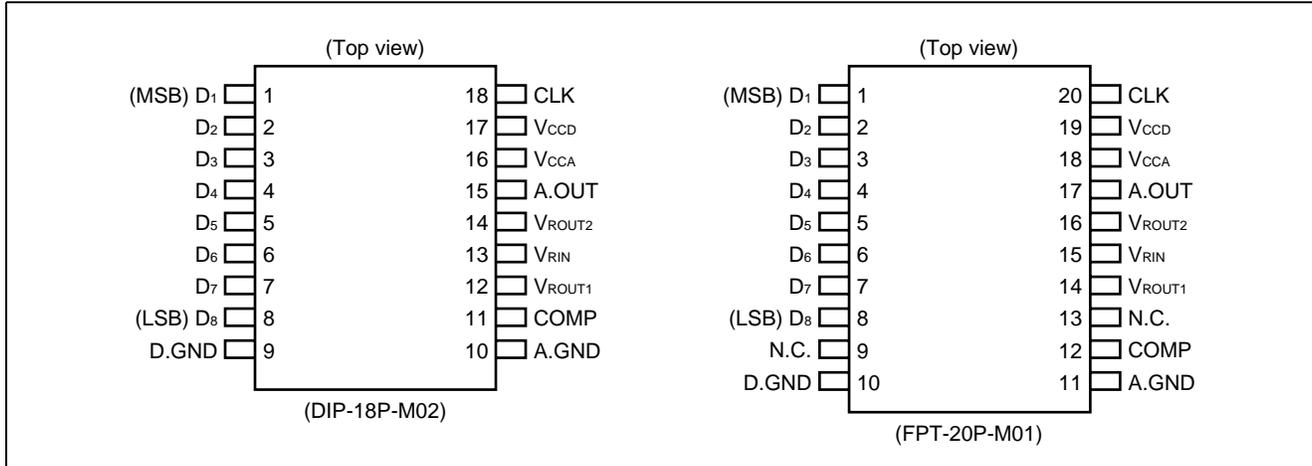
## ■ PIN DESCRIPTIONS

| Pin No. DIP | Pin No. SOP | Pin name | I/O | Description |
|---|---|---|---|---|
| 1 to 8 | 1 to 8 | D$_1$ to D$_8$ | I | Input pins for data signals (D$_1$: MSB, D$_8$: LSB) |
| 18 | 20 | CLK | I | Input pin for clock signal |
| 17 | 19 | V$_{CCD}$ | — | Digital power supply pin (+5 V) |
| 16 | 18 | V$_{CCA}$ | — | Analog power supply pin (+5 V) |
| 9 | 10 | D.GND | — | Digital ground pin (0 V) |
| 10 | 11 | A.GND | — | Analog ground pin (0 V) |
| 13 | 15 | V$_{RIN}$ | I | Reference voltage input pin.<br>Used for setting dynamic range for analog output.<br>Connect this pin with either V$_{ROUT1}$ or V$_{ROUT2}$ pin when using the internal reference voltage.<br>When using the external reference voltage, use it within the range of 2.65 to 4.3 V or for the V$_{CCA}$ – V$_{RIN}$ range of 0.7 to 2.2 V. |
| 12 | 14 | V$_{ROUT1}$ | O | Reference voltage output pin 1.<br>Resistance division reference voltage, with its output voltage set to $0.6 \times V_{CCA}$.<br>This pin, if connected with the V$_{RIN}$ pin, provides V$_{CCA}$ analog output voltage at $0.6 \times V_{CCA}$. |
| 14 | 16 | V$_{ROUT2}$ | O | Reference voltage output pin 2.<br>Band-gap reference voltage, with its output voltage set to V$_{CCA}$ – 2 [V]. This pin, if connected with the V$_{RIN}$ pin, provides the V$_{CCA}$ analog output voltage at V$_{CCA}$ 1 – 2 [V]. |
| 11 | 12 | COMP | — | Phase compensated capacitance pin.<br>Insert the capacitance of 0.1 $\mu$F or more between this pin and the A.GND for the phase compensated capacitance. |
| 15 | 17 | A.OUT | O | Analog signal output pin |
| — | 9, 13 | N.C. | — | No connection pins |

# ■ BLOCK DIAGRAM
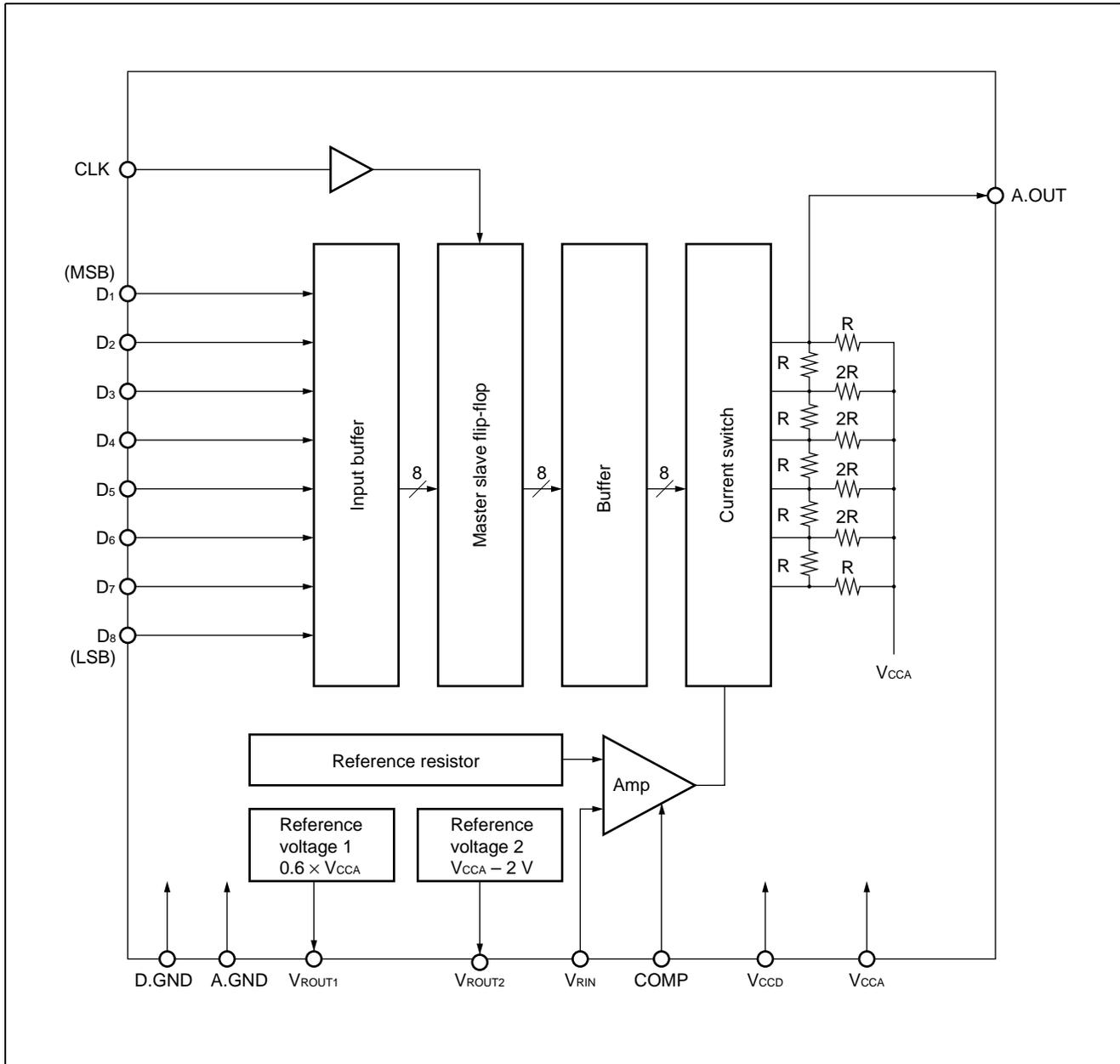
# MB40768H

## ■ ABSOLUTE MAXIMUM RATINGS (See WARNING)

(A.GND = D.GND = 0 V)

| Parameter | | Symbol | Rating | Units |
|---|---|---|---|---|
| Power supply voltage | Analog power supply voltage | $V_{CCA}$ | –0.5 to +7.0 | V |
| | Digital power supply voltage | $V_{CCD}$ | –0.5 to +7.0 | V |
| | Power supply voltage difference | $V_{CCD} - V_{CCA}$ | 1.5 | V |
| Digital signal input voltage | | $V_{ID}$ | –0.5 to +7.0 | V |
| Storage temperature | | Tstg | –55 to +125 | °C |

**WARNING:** Permanent device damage may occur if the above **Absolute Maximum Ratings** are exceeded. Functional operation should be restricted to the conditions as detailed in the operational sections of this data sheet. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## ■ RECOMMENDED OPERATING CONDITIONS

(A.GND = D.GND = 0 V)

| Parameter | | Symbol | Value | | | Units |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| Power supply voltage | Analog power supply voltage | $V_{CCA}$ | 4.75 | 5.00 | 5.25 | V |
| | Digital power supply voltage | $V_{CCD}$ | 4.75 | 5.00 | 5.25 | V |
| | Power supply voltage difference | $V_{CCA} - V_{CCD}$ | –0.2 | — | 0.2 | V |
| Analog reference voltage | | $V_{CCA} - V_{RIN}$ | 0.70 | 2.00 | 2.20 | V |
| | | $V_{RIN}$ | 2.65 | 3.00 | 4.30 | V |
| Digital High level input voltage | | $V_{IHD}$ | 2.0 | — | — | V |
| Digital Low level input voltage | | $V_{ILD}$ | — | — | 0.8 | V |
| Clock frequency | | $f_{CLK}$ | — | — | 60 | MHz |
| Setup time | | $t_{su}$ | 8 | — | — | ns |
| Hold time | | $t_h$ | 2 | — | — | ns |
| High level minimum pulse width | | $t_{wH}$ | 6.5 | — | — | ns |
| Low level minimum pulse width | | $t_{wL}$ | 6.5 | — | — | ns |
| Phase compensated capacitance | | $C_{COMP}$ | 0.1 | — | — | µF |
| Operating ambient temperature | | Top | –20 | — | +75 | °C |

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## ■ ELECTRIC CHARACTERISTICS

### 1. DC Characteristics

$(V_{CCA} = V_{CCD} = 4.75 \text{ V to } 5.25 \text{ V, A.GND} = \text{D.GND} = 0 \text{ V, Ta} = -20°C \text{ to } +75°C)$

| Parameter | | Symbol | Condition | Value | | | Units |
|---|---|---|---|---|---|---|---|
| | | | | Min. | Typ. | Max. | |
| Resolution | | — | — | — | — | 8 | bit |
| Linearity error | | LE | DC precision | — | — | ±0.2 | % |
| Digital High level input current | | $I_{IHD}$ | $V_{IHD}$ = 2.7 V | — | — | 20 | μA |
| Digital Low level input current | | $I_{ILD}$ | $V_{ILD}$ = 0.4 V | −100 | — | — | μA |
| Reference input current | | $I_{RIN}$ | $V_{RIN}$ = 3.000 V | — | — | 10 | μA |
| Resistance division method | Reference voltage | $V_{ROUT1}$ | $V_{CCA}$ = 5.00 V $V_{CCD}$ = 5.00 V | 2.900 | 3.000 | 3.100 | V |
| Band-gap reference method | Reference voltage | $V_{ROUT2}$ | — | $V_{CCA}$ – 2.100 | $V_{CCA}$ – 2.000 | $V_{CCA}$ – 1.900 | V |
| | Temperature coefficient | — | — | — | 100 | — | ppm/°C |
| Full-scale output voltage | | $V_{OFS}$ | — | $V_{CCA}$ – 20 | $V_{CCA}$ | — | mV |
| Zero-scale output voltage | | $V_{OZS}$ | $V_{CCA}$ = 5.00 V $V_{CCD}$ = 5.00 V $V_{RIN}$ = 3.000 V | 2.938 | 3.008 | 3.078 | V |
| Output resistance | | $R_O$ | Ta = +25°C | 192 | 240 | 288 | Ω |
| Current consumption | | $I_{CC}$ | $V_{CCA}$ = 5.25 V $V_{CCD}$ = 5.25 V $V_{RIN}$ = $V_{ROUT1}$ | — | 32* | 56 | mA |

* : $V_{CCA} = V_{CCD} = 5 \text{ V}$

### 2. AC Characteristics

$(V_{CCA} = V_{CCD} = 4.75 \text{ V to } 5.25 \text{ V, A.GND} = \text{D.GND} = 0 \text{ V, Ta} = -20°C \text{ to } +75°C)$

| Parameter | Symbol | Condition | Value | | | Units |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| Maximum conversion rate | $F_s$ | $C_L$ = 15 pF Terminal resistance at A.OUT pin = 240 Ω | 60 | — | — | MSPS |
| Output propagation time | $t_{pd}$ | | — | 7 | — | ns |
| Output rise time | $t_r$ | | — | 5 | — | ns |
| Output fall time | $t_f$ | | — | 5 | — | ns |
| Settling time | $t_{set}$ | | — | 15 | — | ns |

# MB40768H

■ **TIMING DIAGRAM**
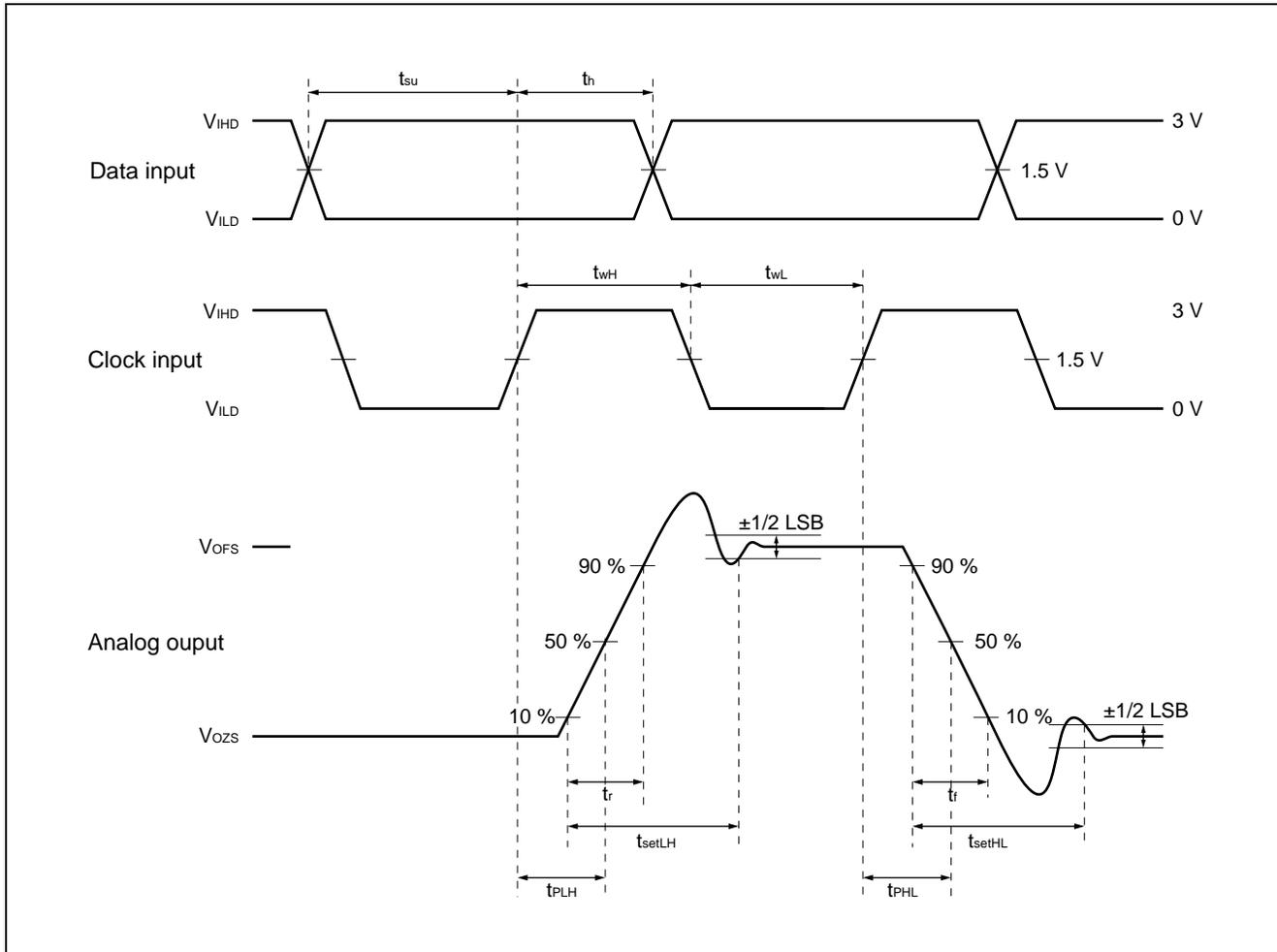
## ■ DIGITAL INPUT EQUIVALENT CIRCUIT
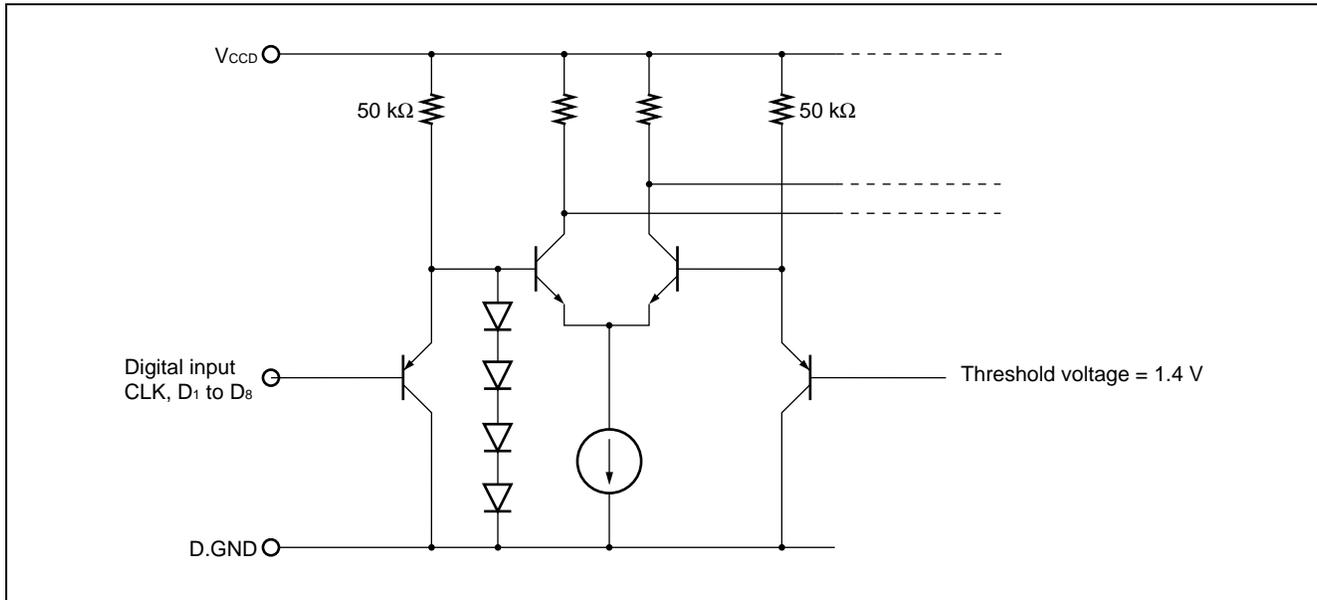


## ■ ANALOG OUTPUT EQUIVALENT CIRCUIT
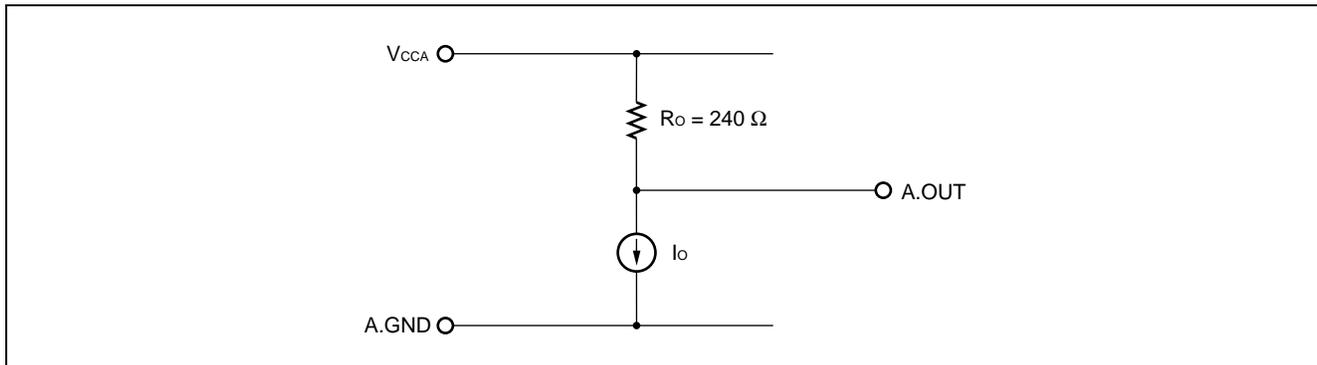


## ■ REFERENCE VOLTAGE OUTPUT EQUIVALENT CIRCUIT



*: Overcurrent protection resistor (2 kΩ) when short-circuited to GND.

7
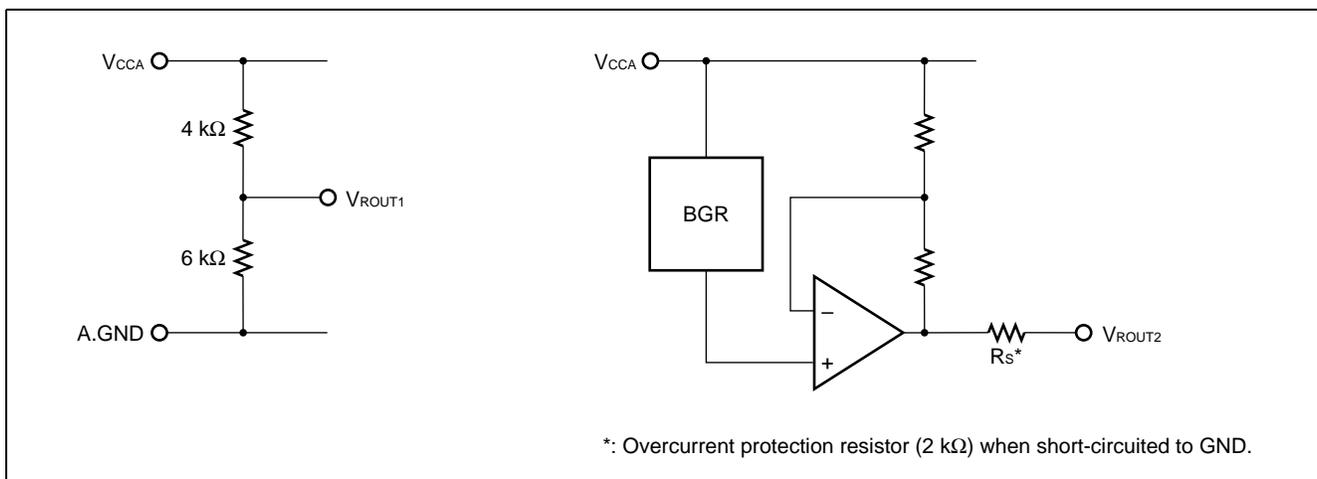
■ **DAC OUTPUT VOLTAGE CHARACTERISTIC**

| Input | | Output | |
|---|---|---|---|
| D$_1$ to D$_8$ | | A.OUT | |
| FF | (V$_{CCA}$)<br>V$_{OFS}$ | 5.000 V<br>5.000 V | |
| 00 | V$_{OZS}$<br>(V$_{RIN}$) | 3.008 V<br>3.000 V | |

1 LSB ≒ 8 mV
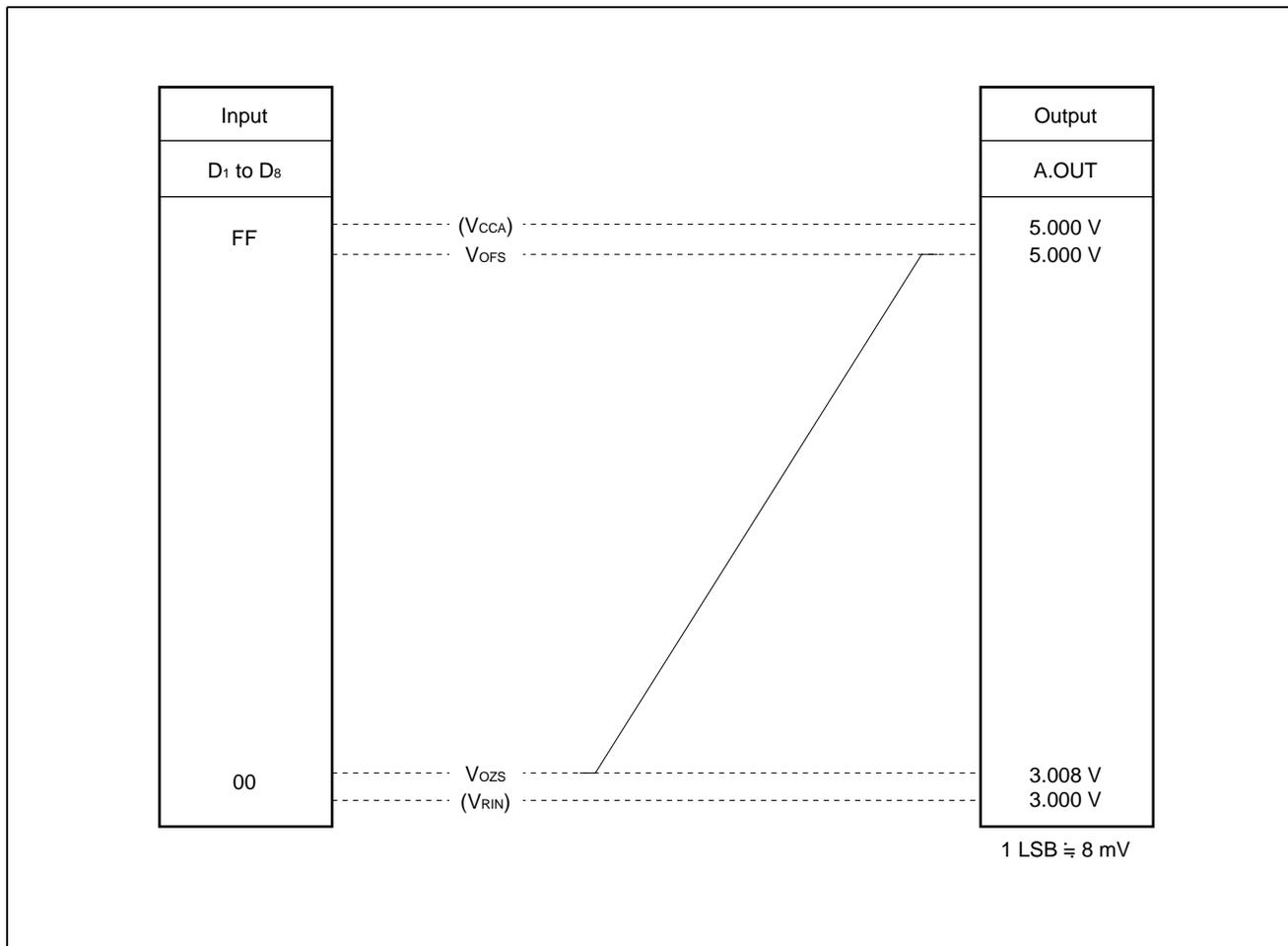
■ **EQUATION FOR IDEAL DAC OUTPUT VOLTAGE**

$$\text{A.OUT} = V_{CCA} - \frac{255 - N}{256} \times (V_{CCA} - V_{RIN})$$

(N: digital input code for 0 to 255)

$$V_{OFS} = V_{CCA}$$

$$V_{OZS} = V_{CCA} - \frac{255}{256} \times (V_{CCA} - V_{RIN})$$

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## ■ STANDARD EXAMPLE OF CONNECTION
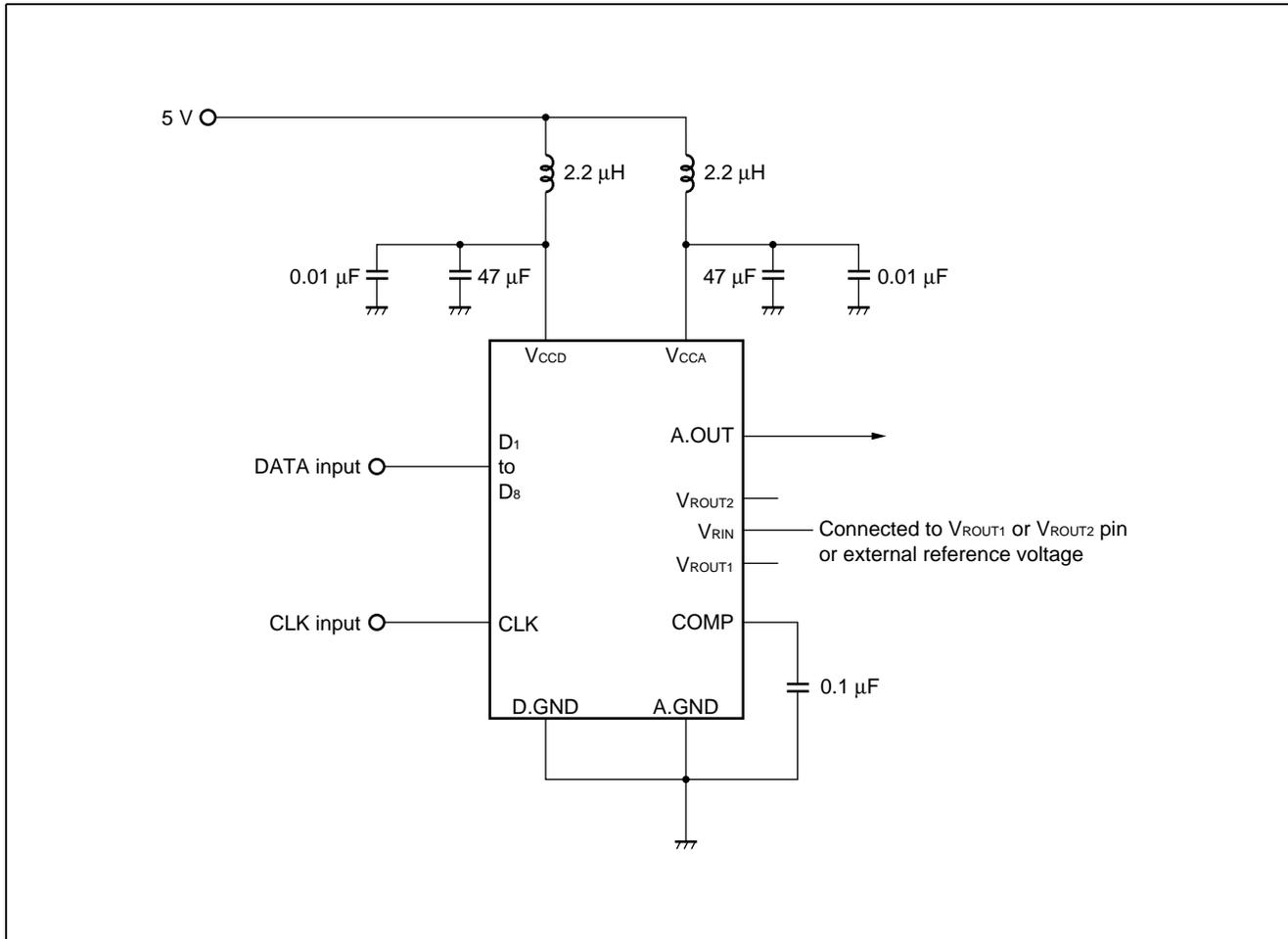


## ■ NOTES ON USAGE

- **Countermeasures for switching noise**

  To prevent the switching noise riding on the analog output signal to the maximum possible extent, insert the noise limiting capacitor between $V_{CCA}$-A.GND pins, and between $V_{CCD}$-D.GND pins closest as possible to the IC pins.

- **Power supply patterns**

  To reduce parasitic impedance, use the patterns as wide as possible to be connected to the $V_{CCA}$, $V_{CCD}$, A.GND and D.GND pins.

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# MB40768H

## ■ TYPICAL CHARACTERISTIC CURVES

1. Power supply current vs Ambient temperature
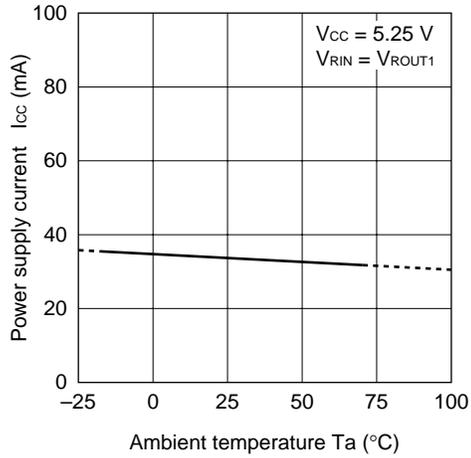


2. Linearity error vs Ambient temperature
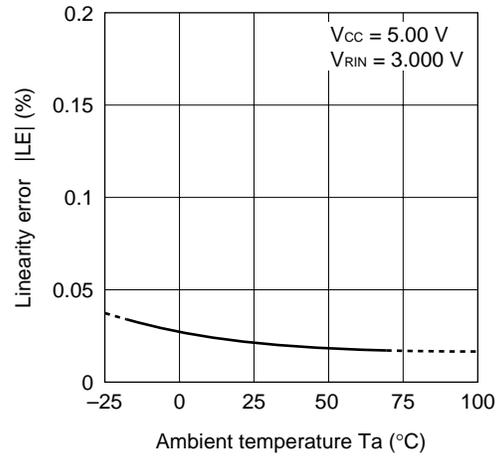


3. Output resistance vs Ambient temperature
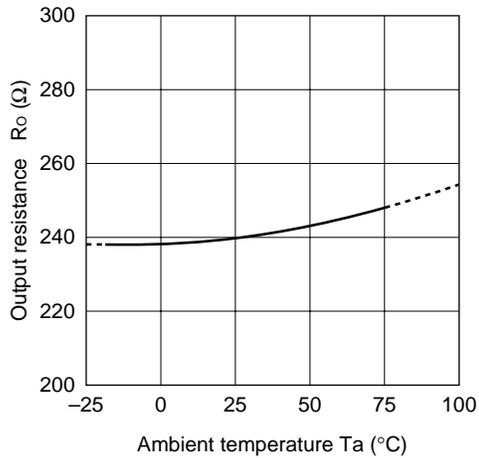


4. Full-scale output voltage vs Ambient temperature
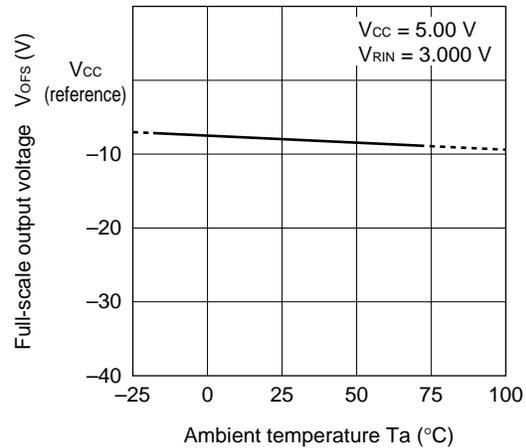


5. Zero-scale output voltage vs Ambient temperature
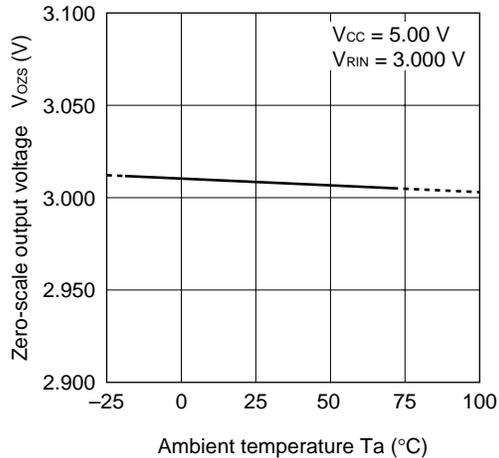


6. $V_{ROUT1}$ reference output voltage vs Ambient temperature



*(Continued)*

10
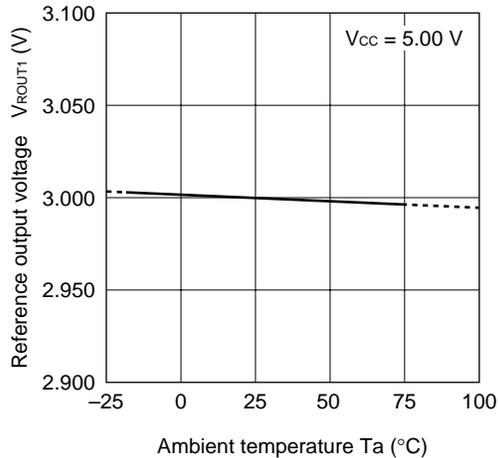
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7. V$_{ROUT2}$ reference output vs Ambient temperature
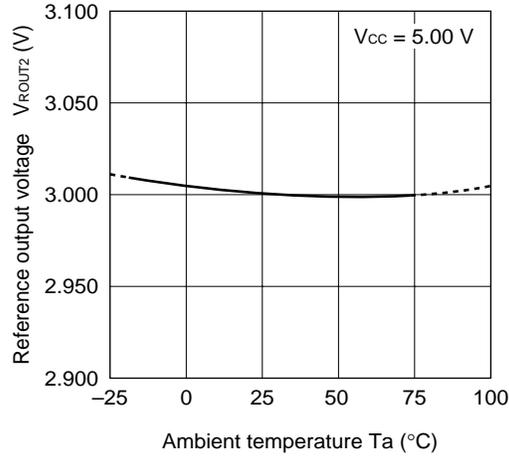


8. V$_{ROUT2}$ reference output voltage vs Power supply voltage
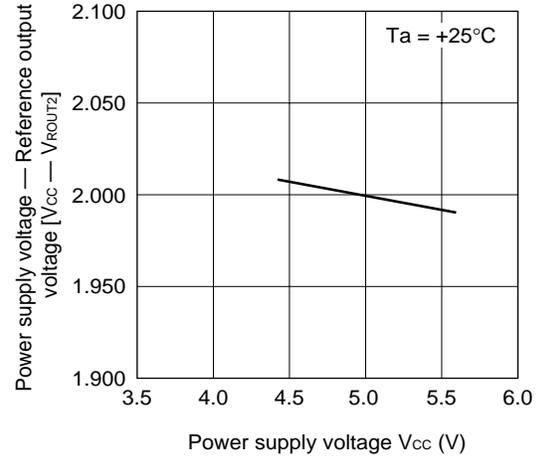


9. Setup time vs Ambient temperature
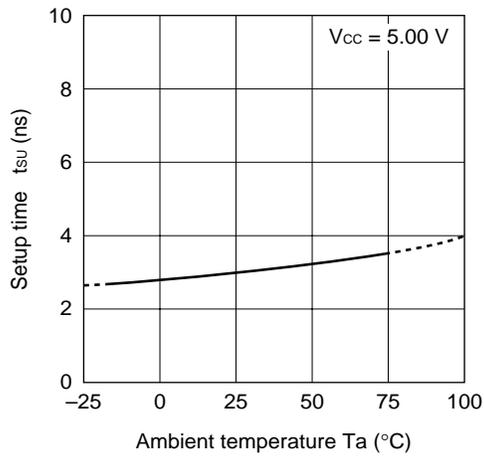


10. Setup time vs Power supply voltage
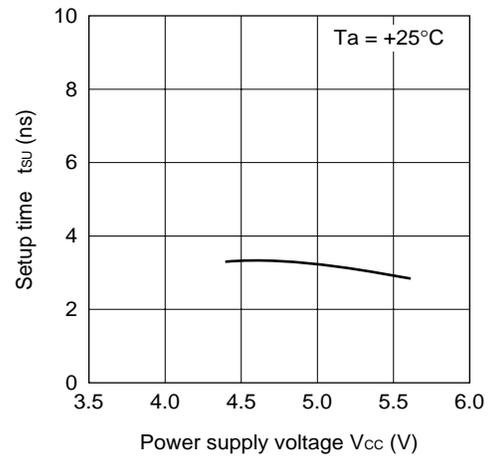


11. Hold time vs Ambient temperature
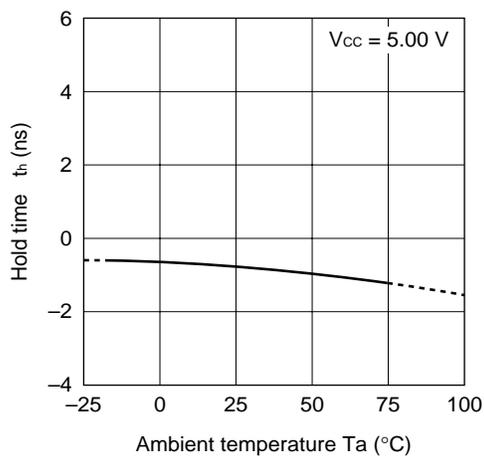


12. Hold time vs Power supply voltage



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# MB40768H
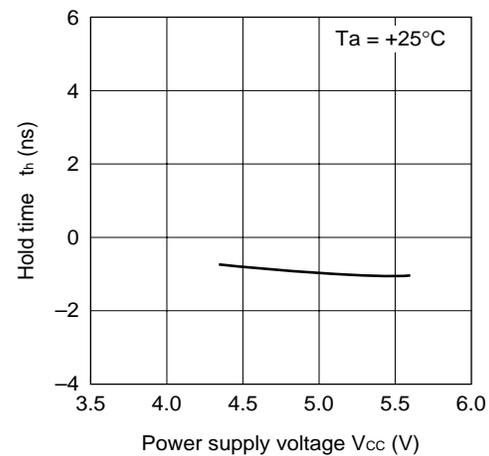
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### 13. Minimum clock pulse width vs Ambient temperature



Vcc = 5.00 V

Minimum clock pulse width  $t_{wL}$, $t_{wH}$ (ns)

Ambient temperature Ta (°C)

$t_{wl}$
$t_{wh}$
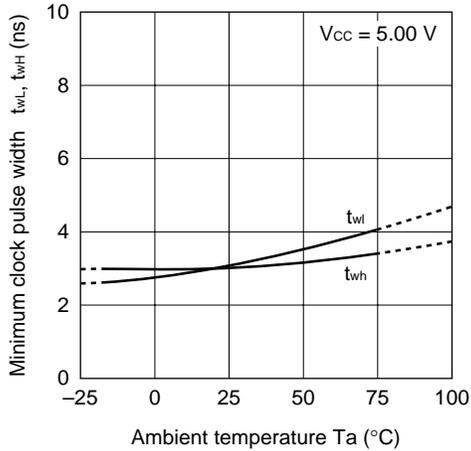
### 14. Minimum clock pulse width vs Power supply voltage



Ta = +25°C

Minimum clock pulse width  $t_{wL}$, $t_{wH}$ (ns)

Power supply voltage Vcc (V)

$t_{wh}$
$t_{wl}$
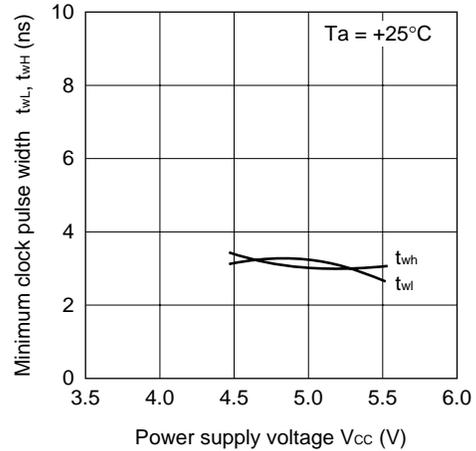
### 15. Rise time, Fall time vs Ambient temperature



Vcc = 5 V
VRIN = 3.000 V
CL = 15 pF
Analog output terminated
with 240 Ω (1 V amplitude)

Rise time  $t_r$, fall time  $t_f$ (ns)

Ambient temperature Ta (°C)
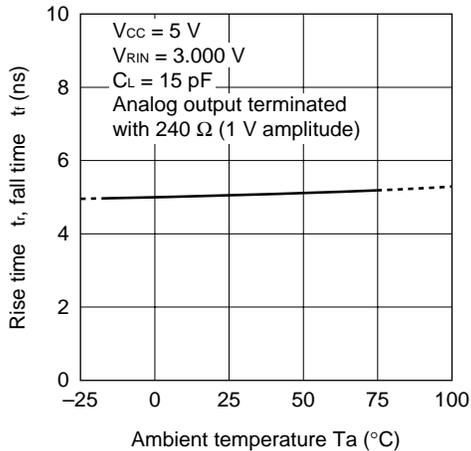
### 16. Rise time, Fall time vs Power supply voltage



Ta = +25°C
VRIN = 3.000 V
CL = 15 pF
Analog output terminated
with 240 Ω (1 V amplitude)

Rise time  $t_r$, fall time  $t_f$ (ns)

Power supply voltage Vcc (V)
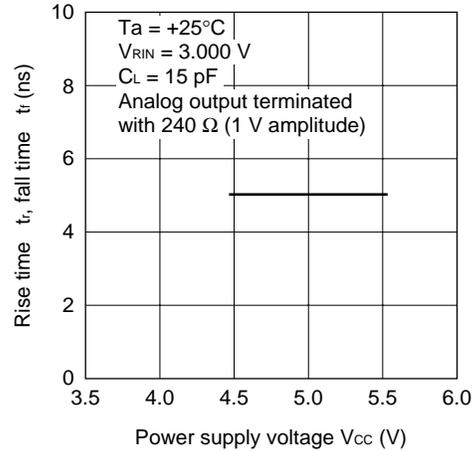
### 17. Delay time vs Ambient temperature



Vcc = 5 V
VRIN = 3.000 V
CL = 15 pF
Analog output terminated
with 240 Ω (1 V amplitude)

Delay time  $t_{PLH}$, $t_{PHL}$ (ns)

Ambient temperature Ta (°C)
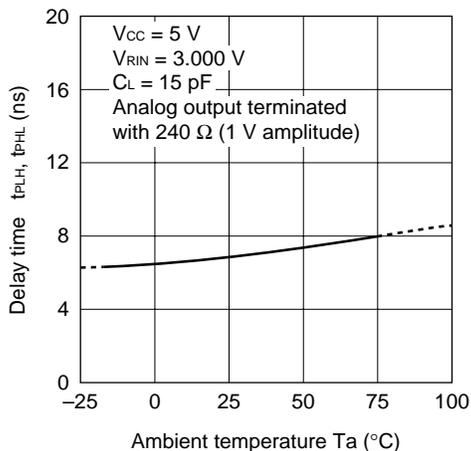
### 18. Delay time vs Power supply voltage



Ta = +25°C
VRIN = 3.000 V
CL = 15 pF
Analog output terminated
with 240 Ω (1 V amplitude)

Delay time  $t_{PLH}$, $t_{PHL}$ (ns)

Power supply voltage Vcc (V)

12
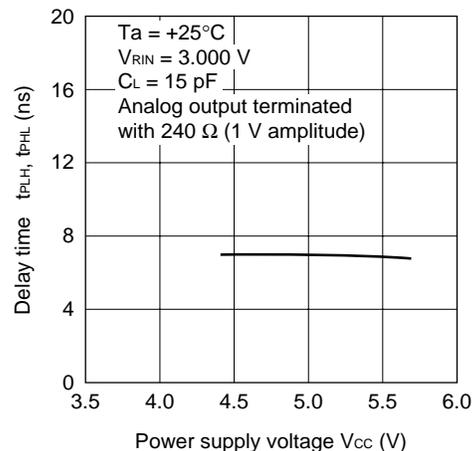
## ■ ORDERING INFORMATION

| Part number | Package | Remarks |
|---|---|---|
| MB40768HP | 18-pin Plastic DIP<br>(DIP-18P-M02) | |
| MB40768HPF | 20-pin Plastic SOP<br>(FPT-20P-M01) | |

## ■ PACKAGE DIMENSIONS

18-pin Plastic DIP
(DIP-18P-M02)



$22.05^{+0.20}_{-0.30}$
$\left(.868^{+.008}_{-.012}\right)$

INDEX-1

INDEX-2

$6.20\pm0.25$
$(.244\pm.010)$

5.00(.197)MAX

3.00(.118)MIN

0.51(.020)MIN

$0.45^{+0.14}_{-0.05}$
$\left(.018^{+.006}_{-.002}\right)$

$0.25\pm0.05$
$(.010\pm.002)$

$1.20^{+0.30}_{-0}$
$\left(.047^{+.012}_{-0}\right)$

$1.20^{+0.30}_{-0}$
$\left(.047^{+.012}_{-0}\right)$

1.27(.050)
MAX

2.54(.100)
TYP

7.62(.300)
TYP

15°MAX
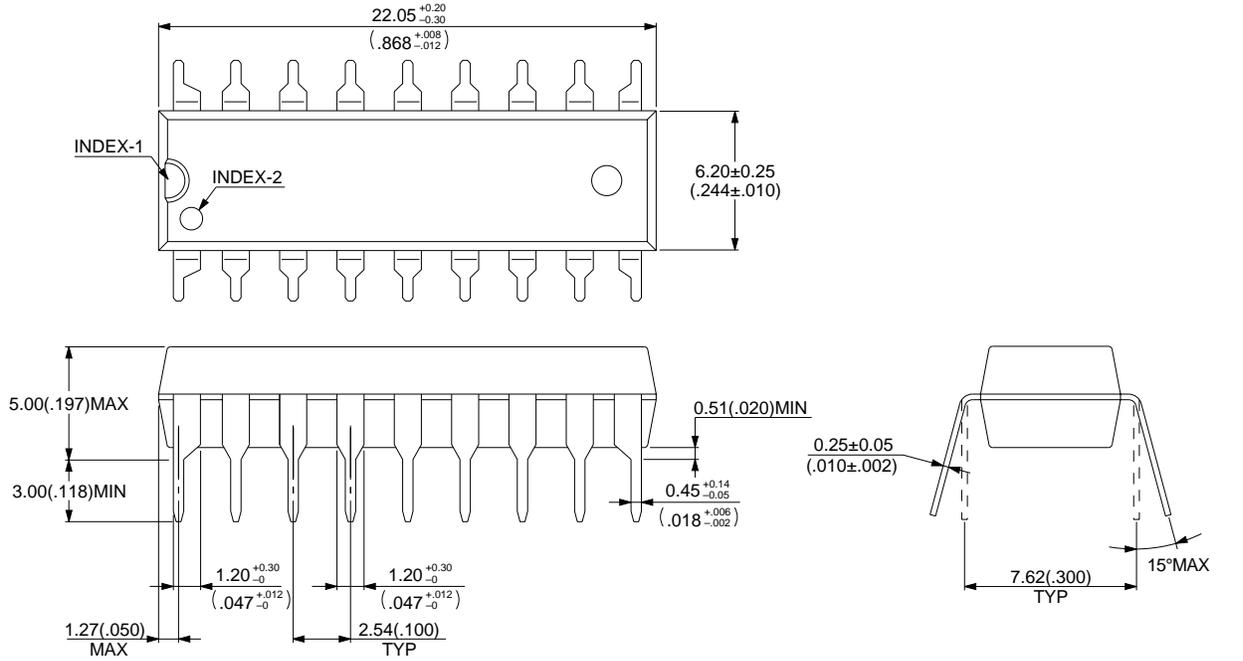
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Dimensions in mm (inches)

*(Continued)*

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20-pin Plastic SOP
(FPT-20P-M01)



Dimensions in mm (inches)
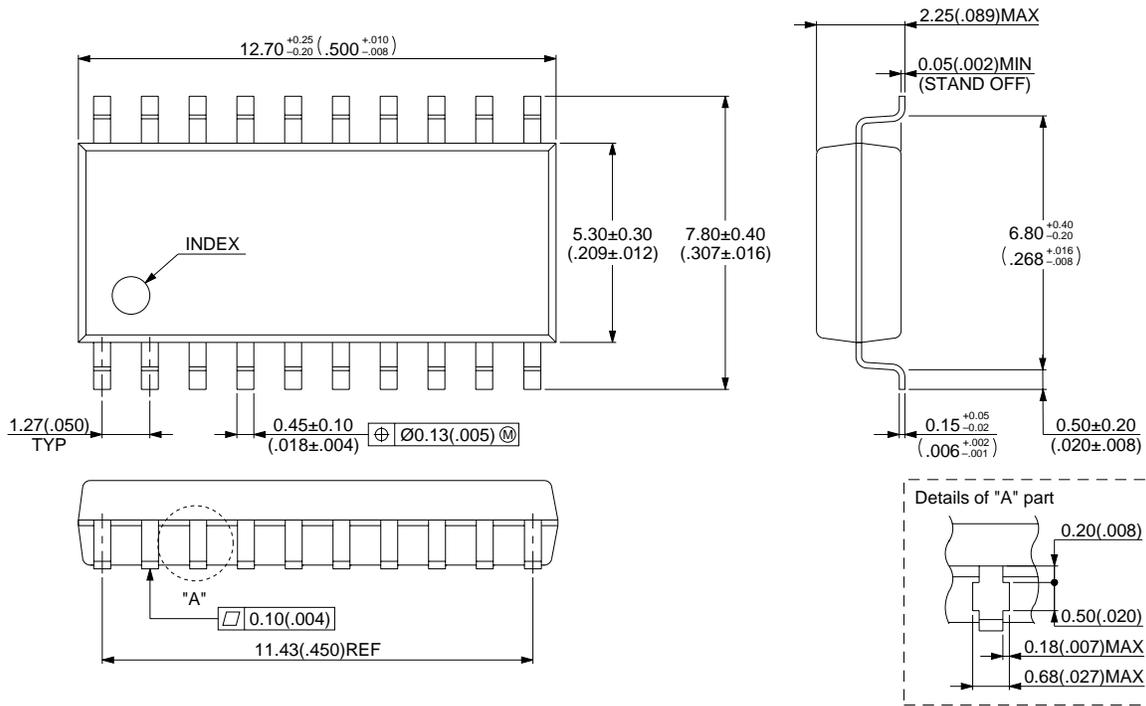
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