FUJITSU SEMICONDUCTOR
DATA SHEET

DS04-13506-3E

*Linear IC General purpose Converter*

**CMOS**

# D/A Converter for Digital Tuning

## (8 channels. 8-bit, with OP amplifier)

# MB88347

## ■ DESCRIPTION

The MB88347 features 8 channels of 8-bit D/A converters (with output amplifiers). The output amplifier provides high current drive capability. As data is input via a serial link, only three control lines are required, and cascaded connections can be used.

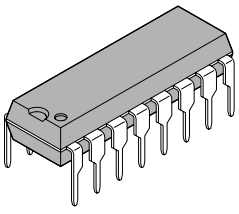
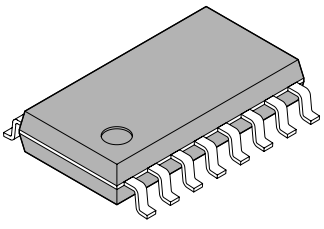
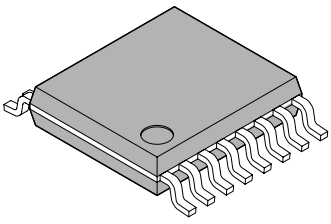
The MB88347 is suitable for electronic volumes and replacement for potentiometers for adjustment, in addition to normal D/A converter applications.

## ■ FEATURES

- Low power consumption (2 mW/ch)
- Small package
- Integrating 8 channels of R-2R type 8-bit D/A converter.

*(Continued)*

## ■ PACKAGES

| 16-pin plastic DIP | 16-pin plastic SOP | 16-pin plastic SSOP |
|---|---|---|
|  |  |  |
| (DIP-16P-M04) | (FPT-16P-M06) | (FPT-16P-M05) |

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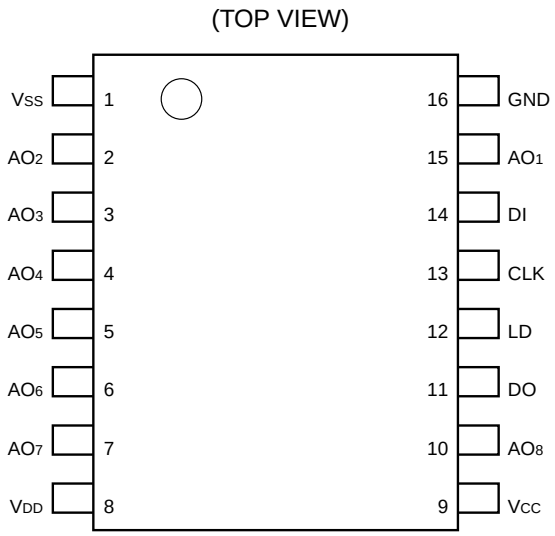
*(Continued)*

- Built-in analog output amplifier (Max +1.0 mA sink/source current)
- Analog output range : 0 to $V_{CC}$
- The range of D/A conversion can be independently set by separated the power supply for MCU interface and OP amplifier and the power supply for D/A converter.
- Capable of being controlled directly by a 3-V MCU (input voltage : “H” = 0.5 $V_{CC}$, “L” = 0.2 $V_{CC}$)
- Serial data input, 2.5 MHz operation
- CMOS process
- Package lineup : DIP 16-pin, SOP 16-pin, SSOP 16-pin

## ■ PIN ASSIGNMENT



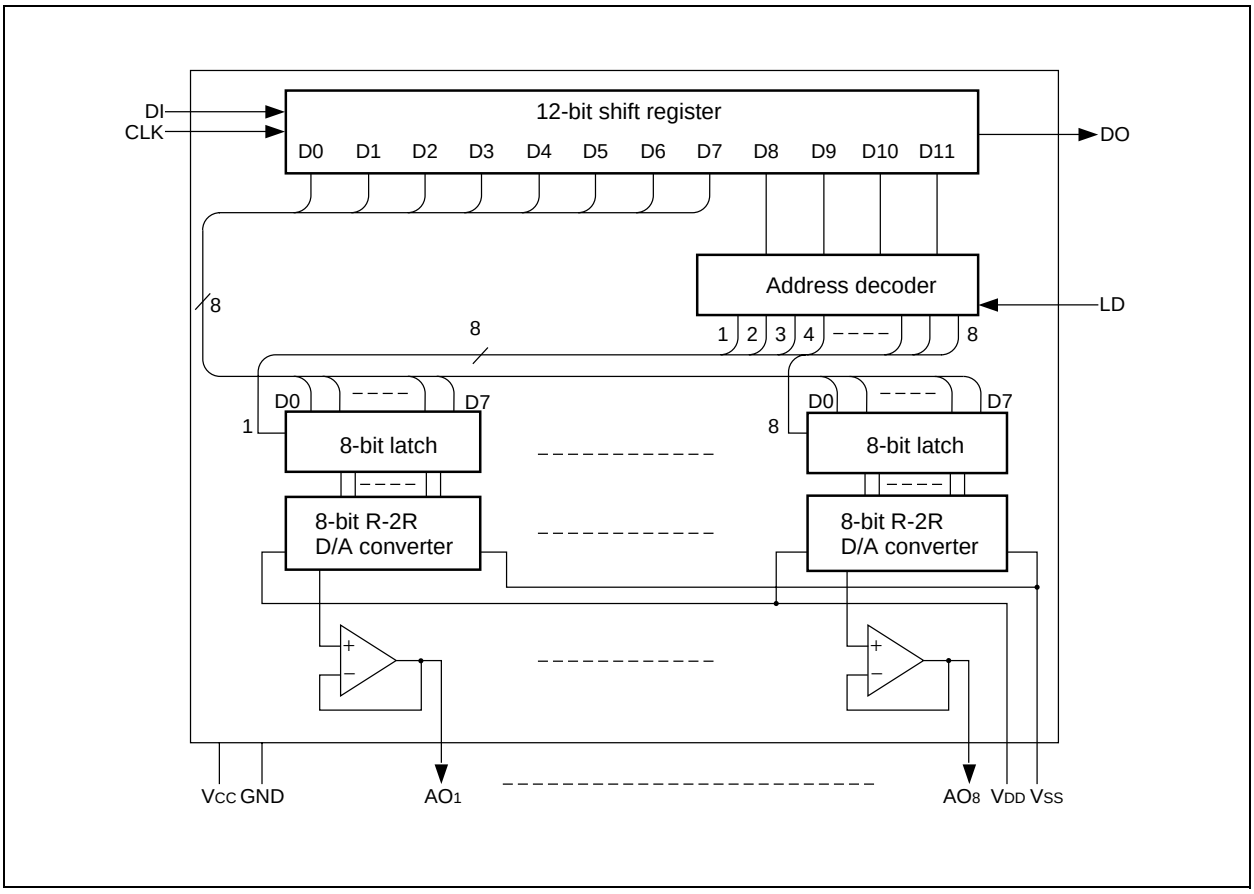

(DIP-16P-M04)
(FPT-16P-M06)
(FPT-16P-M05)

## ■ PIN DESCRIPTION

| Pin No. | Symbol | I/O | Pin name | Function |
|---|---|---|---|---|
| 14 | DI* | I | Data input pin | Serial data input pin.<br>This pin inputs 12-bit length serial data. |
| 11 | DO | O | Data output pin | This pin outputs MSB bit data of 12-bit shift register. |
| 13 | CLK* | I | Shift clock input pin | Shift clock input pin.<br>The input signal from the DI pin is inputted to a 12-bit shift register on the rising edge of the shift clock. |
| 12 | LD* | I | Load signal input pin | If input “H” level to LD pin, the data of shift register is loaded to the decoder and the register for D/A output. |
| 15<br>2<br>3<br>4<br>5<br>6<br>7<br>10 | $AO_1$<br>$AO_2$<br>$AO_3$<br>$AO_4$<br>$AO_5$<br>$AO_6$<br>$AO_7$<br>$AO_8$ | O | D/A output pin | These pins are 8-bit D/A output with OP amplifier. |
| 9 | $V_{CC}$ | — | Power supply pin | Power supply pin of MCU interface and OP amplifier |
| 16 | GND | — | Ground pin | Ground pin of MCU interface and OP amplifier |
| 8 | $V_{DD}$ | — | Power supply pin | Power supply pin of D/A converter |
| 1 | $V_{SS}$ | — | Ground pin | Ground pin of D/A converter |

* : DI, CLK, and LD pins are fixed to “L” level at non transfer.

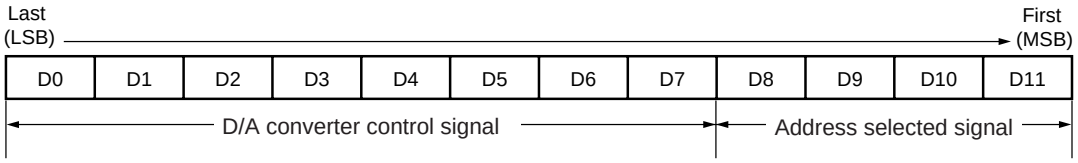
## ■ BLOCK DIAGRAM



## ■ DATA FOR CHIP CONTROL

### 1. Data for Shift Register

- MB88347 has 12-bit shift register for chip control.
- It is necessary to set the data as following configuration to 12-bit shift register.
- The data consists of 12 bits: a 4-bit address selection and an 8-bit D/A converter control signal.




### 2. D/A Converter Control Signal

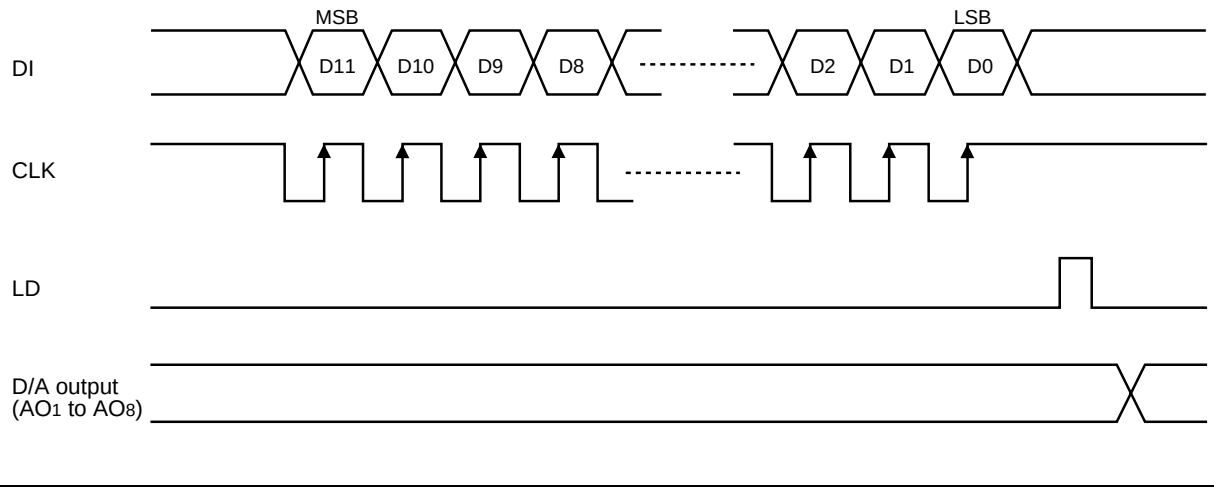
| Input data signal | | | | | | | | D/A converter output voltage |
|---|---|---|---|---|---|---|---|---|
| D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ≒ $V_{SS}$ |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ≒ $V_{LB} + V_{SS}$ |
| 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | ≒ $V_{LB} \times 2 + V_{SS}$ |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | ≒ $V_{LB} \times 254 + V_{SS}$ |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | ≒ $V_{DD}$ |

$V_{LB} = (V_{DD} - V_{SS}) /255$

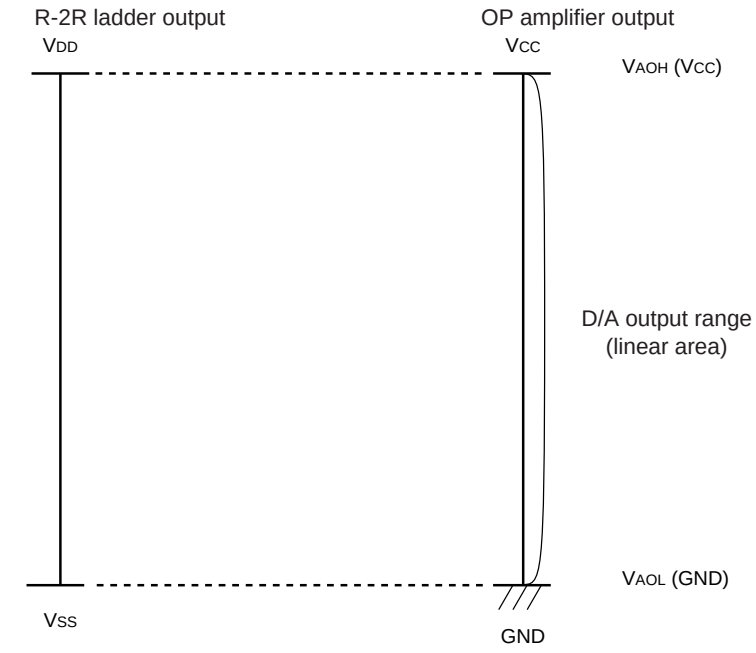
### 3. Address Selected Signal

| Input data signal | | | | Address selected |
|---|---|---|---|---|
| D8 | D9 | D10 | D11 | |
| 0 | 0 | 0 | 0 | Don't Care |
| 0 | 0 | 0 | 1 | $AO_1$ selected |
| 0 | 0 | 1 | 0 | $AO_2$ selected |
| 0 | 0 | 1 | 1 | $AO_3$ selected |
| 0 | 1 | 0 | 0 | $AO_4$ selected |
| 0 | 1 | 0 | 1 | $AO_5$ selected |
| 0 | 1 | 1 | 0 | $AO_6$ selected |
| 0 | 1 | 1 | 1 | $AO_7$ selected |
| 1 | 0 | 0 | 0 | $AO_8$ selected |
| 1 | 0 | 0 | 1 | Don’t Care |
| 1 | 0 | 1 | 0 | Don’t Care |
| 1 | 0 | 1 | 1 | Don’t Care |
| 1 | 1 | 0 | 0 | Don’t Care |
| 1 | 1 | 0 | 1 | Don’t Care |
| 1 | 1 | 1 | 0 | Don’t Care |
| 1 | 1 | 1 | 1 | Don’t Care |

## ■ TIMING CHART AT DATA SETTING




## ■ ANALOG OUTPUT VOLTAGE RANGE




Note : $V_{CC} = V_{DD}$, GND = $V_{SS}$

## ■ ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Condition | Rating | | Unit |
|---|---|---|---|---|---|
| | | | Min | Max | |
| Power supply voltage | $V_{CC}$ | The case that GND is reffered. Ta = +25 °C | − 0.3 | + 7.0 | V |
| | $V_{DD}$ | | − 0.3* | + 7.0* | V |
| Input voltage | $V_{IN}$ | | − 0.3 | $V_{CC}$ + 0.3 | V |
| Output voltage | $V_{OUT}$ | | − 0.3 | $V_{CC}$ + 0.3 | V |
| Power consumption | $P_D$ | — | — | 250 | mW |
| Operating temperature | Ta | — | − 40 | + 85 | °C |
| Storage temperature | Tstg | — | − 55 | + 150 | °C |

* : $V_{CC} \geq V_{DD}$

WARNING: Semiconductor devices can be permanently damaged by application of stress (voltage, current, temperature, etc.) in excess of absolute maximum ratings. Do not exceed these ratings.

## ■ RECOMMENDED OPERATING CONDITIONS

| Parameter | Symbol | Condition | Value | | Unit |
|---|---|---|---|---|---|
| | | | Min | Max | |
| Power supply Voltage 1 | $V_{CC}$ | — | 4.5 | 5.5 | V |
| | GND | — | — | 0 | V |
| Power supply Voltage 2 | $V_{DD}$ | $V_{DD} - V_{SS} \geq 2.0$ V | 2.0 | $V_{CC}$ | V |
| | $V_{SS}$ | | GND | $V_{CC}$ − 2.0 | V |
| Analog output source current | $I_{AL}$ | — | — | 1.0 | mA |
| Analog output sink current | $I_{AH}$ | — | — | 1.0 | mA |
| Oscillation limited output capacitance | $C_{OL}$ | — | — | 1.0 | µF |
| Digital data setting range | — | — | #00 | #FF | — |
| Operating temperature | Ta | — | − 40 | + 85 | °C |

WARNING: The recommended operating conditions are required in order to ensure the normal operation of the semiconductor device. All of the device's electrical characteristics are warranted when the device is operated within these ranges.

Always use semiconductor devices within their recommended operating condition ranges. Operation outside these ranges may adversely affect reliability and could result in device failure.

No warranty is made with respect to uses, operating conditions, or combinations not represented on the data sheet. Users considering application outside the listed conditions are advised to contact their FUJITSU representatives beforehand.

## ■ ELECTRICAL CHARACTERISTICS

### 1. DC Characteristics

#### (1) Digital block

($V_{DD}$, $V_{CC}$ = + 5 V ± 10% ($V_{CC} \geq V_{DD}$) , GND, $V_{SS}$ = 0 V, Ta = − 40 °C to + 85 °C)

| Parameter | Symbol | Pin name | Conditions | Value | | | Unit |
|---|---|---|---|---|---|---|---|
| | | | | Min | Typ | Max | |
| Power supply voltage | $V_{CC}$ | $V_{CC}$ | — | 4.5 | 5.0 | 5.5 | V |
| Power supply current | $I_{CC}$ | | At CLK = 1 MHz operating (at no load) At Ta = − 20 °C to + 85 °C | — | 0.8 | 1.8 | mA |
| | | | At CLK = 1 MHz operating (at no load) At Ta = − 40 °C to + 85 °C | — | 0.8 | 2.1 | |
| Input leakage current | $I_{ILK}$ | CLK DI LD | $V_{IN}$ = 0 to $V_{CC}$ | −10 | — | 10 | µA |
| "L" level input voltage | $V_{IL}$ | | — | — | — | 0.2 $V_{CC}$ | V |
| "H" level input voltage | $V_{IH}$ | | — | 0.5 $V_{CC}$ | — | — | V |
| "L" level output voltage | $V_{OL}$ | DO | $I_{OL}$ = 2.5 mA | — | — | 0.4 | V |
| "H" level output voltage | $V_{OH}$ | | $I_{OH}$ = − 400 µA | $V_{CC}$ − 0.4 | — | — | V |

Note : $I_{OL}$ and $I_{OH}$ are output load current.

### (2) Analog block

($V_{DD}$, $V_{CC}$ = + 5 V ± 10% ($V_{CC} \geq V_{DD}$) , GND, $V_{SS}$ = 0 V, Ta = − 40 °C to + 85 °C)

| Parameter | Symbol | Pin name | Conditions | Value | | | Unit |
|---|---|---|---|---|---|---|---|
| | | | | Min | Typ | Max | |
| Consumption current | $I_{DD}$ | $V_{DD}$ | No load | — | 1.0 | 1.5 | mA |
| Analog power supply voltage | $V_{DD}$ | $V_{DD}$ | $V_{DD} - V_{SS} \geq 2.0$ V | 2.0 | — | $V_{CC}$ | V |
| | $V_{SS}$ | $V_{SS}$ | | GND | — | $V_{CC}$ − 2.0 | V |
| Resolution | Res | $AO_1$ to $AO_8$ | — | — | 8 | — | bit |
| Monotonic increase | Rem | | No load<br>$V_{DD} \leq V_{CC}$ − 0.1 V<br>$V_{SS} \geq$ 0.1 V | — | 8 | — | bit |
| Non linearity error*1 | LE | | | −1.5 | — | 1.5 | LSB |
| Differential linearity error*2 | $D_{LE}$ | | | −1.0 | — | 1.0 | LSB |
| Output minimum voltage 1 | $V_{AOL1}$ | $AO_1$ to $AO_8$ | $V_{DD} = V_{CC}$<br>$V_{SS}$ = GND = 0.0 V<br>$I_{AL}$ = 0 µA<br>Digital data = #00 | $V_{SS}$ | — | $V_{SS}$ + 0.1 | V |
| Output minimum voltage 2 | $V_{AOL2}$ | | $V_{DD} = V_{CC}$ = 5.0 V<br>$V_{SS}$ = GND = 0.0 V<br>$I_{AL}$ = 500 µA<br>Digital data = #00 | $V_{SS}$ − 0.2 | $V_{SS}$ | $V_{SS}$ + 0.2 | V |
| Output minimum voltage 3 | $V_{AOL3}$ | | $V_{DD} = V_{CC}$ = 5.0 V<br>$V_{SS}$ = GND = 0.0 V<br>$I_{AH}$ = 500 µA<br>Digital data = #00 | $V_{SS}$ | — | $V_{SS}$ + 0.2 | V |
| Output minimum voltage 4 | $V_{AOL4}$ | | $V_{DD} = V_{CC}$ = 5.0 V<br>$V_{SS}$ = GND = 0.0 V<br>$I_{AL}$ = 1.0 mA<br>Digital data = #00 | $V_{SS}$ − 0.3 | $V_{SS}$ | $V_{SS}$ + 0.3 | V |
| Output minimum voltage 5 | $V_{AOL5}$ | | $V_{DD} = V_{CC}$ = 5.0 V<br>$V_{SS}$ = GND = 0.0 V<br>$I_{AH}$ = 1.0 mA<br>Digital data = #00 | $V_{SS}$ | — | $V_{SS}$ + 0.3 | V |

*(Continued)*

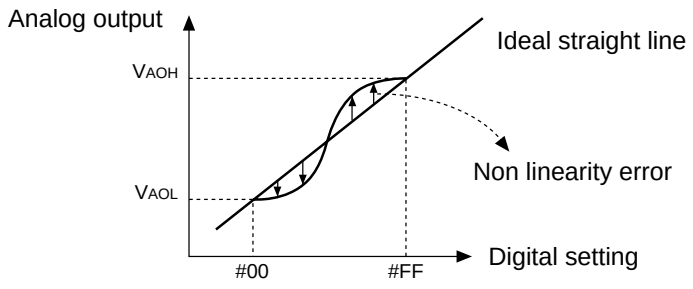
*(Continued)*

($V_{DD}$, $V_{CC}$ = + 5 V ± 10% ($V_{CC} \geq V_{DD}$) , GND, $V_{SS}$ = 0 V, Ta = − 40 °C to + 85 °C)

| Parameter | Symbol | Pin name | Conditions | Value | | | Unit |
|---|---|---|---|---|---|---|---|
| | | | | Min | Typ | Max | |
| Output maximum voltage 1 | $V_{AOH1}$ | $AO_1$ to $AO_8$ | $V_{DD} = V_{CC}$<br>$V_{SS}$ = GND = 0.0 V<br>$I_{AL}$ = 0 µA<br>Digital data = #FF | $V_{DD}$ – 0.1 | — | $V_{DD}$ | V |
| Output maximum voltage 2 | $V_{AOH2}$ | | $V_{DD} = V_{CC}$ = 5.0 V<br>$V_{SS}$ = GND = 0.0 V<br>$I_{AL}$ = 500 µA<br>Digital data = #FF | $V_{DD}$ – 0.2 | — | $V_{DD}$ | V |
| Output maximum voltage 3 | $V_{AOH3}$ | | $V_{DD} = V_{CC}$ = 5.0 V<br>$V_{SS}$ = GND = 0.0 V<br>$I_{AH}$ = 500 µA<br>Digital data = #FF | $V_{DD}$ – 0.2 | $V_{DD}$ | $V_{DD}$ + 0.2 | V |
| Output maximum voltage 4 | $V_{AOH4}$ | | $V_{DD} = V_{CC}$ = 5.0 V<br>$V_{SS}$ = GND = 0.0 V<br>$I_{AL}$ = 1.0 mA<br>Digital data = #FF | $V_{DD}$ – 0.3 | — | $V_{DD}$ | V |
| Output maximum voltage 5 | $V_{AOH5}$ | | $V_{DD} = V_{CC}$ = 5.0 V<br>$V_{SS}$ = GND = 0.0 V<br>$I_{AH}$ = 1.0 mA<br>Digital data = #FF | $V_{DD}$ – 0.3 | $V_{DD}$ | $V_{DD}$ + 0.3 | V |

*1 : Non linearity error : The error of the I/O curve from the ideal straight line between output voltages at "00" and "FF".

*2 : Differential linearity error : The error from the ideal increment given when the digital value is incremented by one bit.




Note: $V_{AOH}$ and $V_{AOL}$ do not always match $V_{DD}$ and $V_{SS}$, respectively.

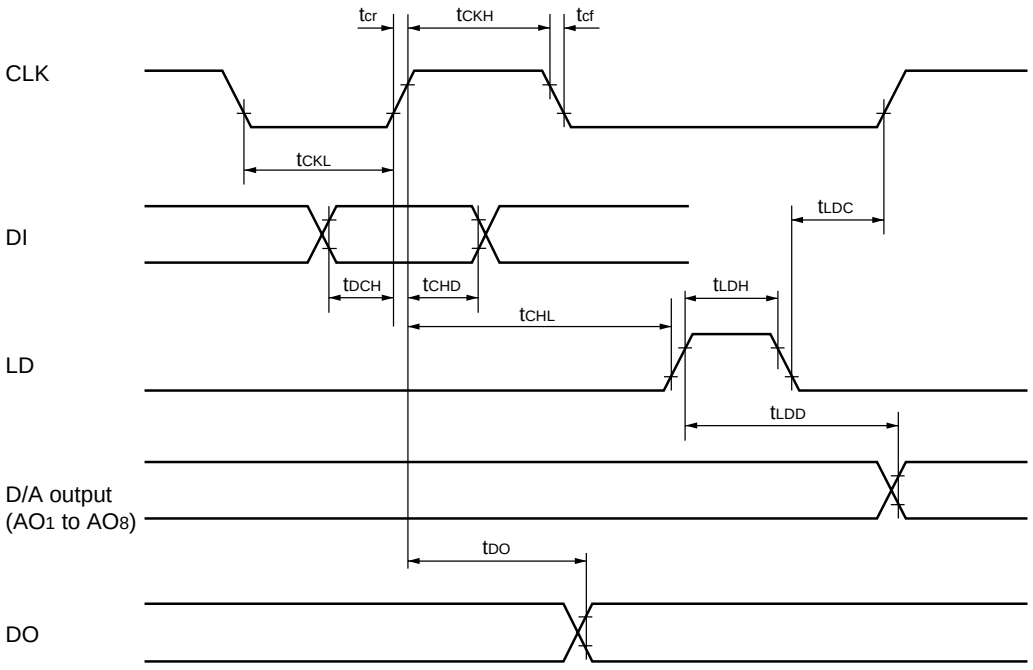
## 2. AC Characteristics

($V_{DD}$, $V_{CC}$ = + 5 V ± 10% ($V_{CC} \geq V_{DD}$) , GND, $V_{SS}$ = 0 V, Ta = − 40 °C to + 85 °C)

| Parameter | Symbol | Conditions | Value | | Unit |
|---|---|---|---|---|---|
| | | | Min | Max | |
| “L” level clock pulse width | $t_{CKL}$ | — | 200 | — | ns |
| “H” level clock pulse width | $t_{CKH}$ | — | 200 | — | ns |
| Clock rising time<br>Clock falling time | $t_{Cr}$<br>$t_{Cf}$ | — | — | 200 | ns |
| Data setup time | $t_{DCH}$ | — | 30 | — | ns |
| Data hold time | $t_{CHD}$ | — | 60 | — | ns |
| Load setup time | $t_{CHL}$ | — | 200 | — | ns |
| Load hold time | $t_{LDC}$ | — | 100 | — | ns |
| “H” level load pulse width | $t_{LDH}$ | — | 100 | — | ns |
| Data output delay time | $t_{DO}$ | Refer to “Load condition (1) ”. | 70 | 350 | ns |
| D/A output settling time | $t_{LDD}$ | Refer to “Load condition (2) ”. | — | 100 | µs |

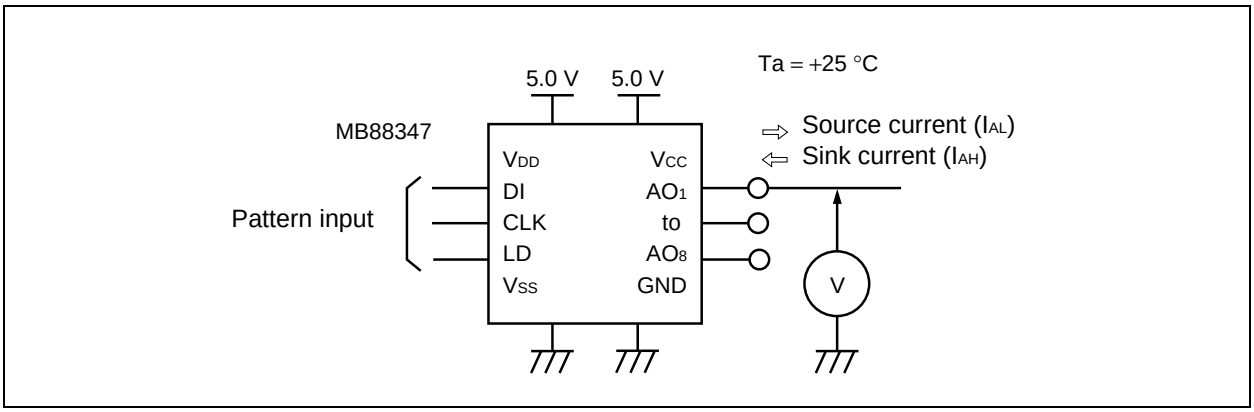
• Load condition

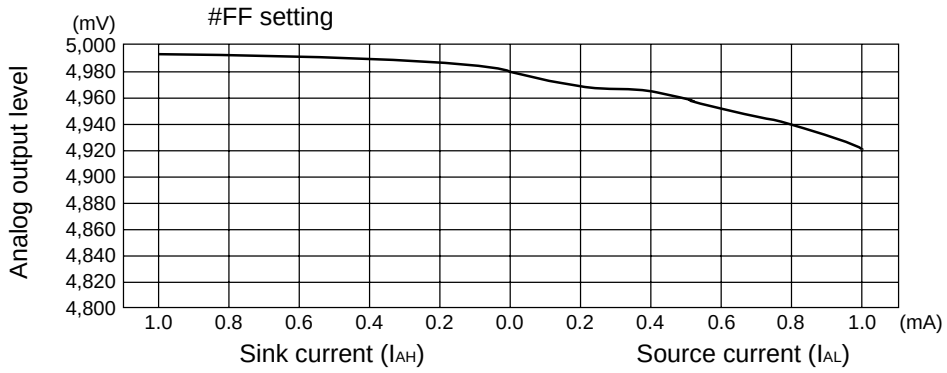
• Input/output timing

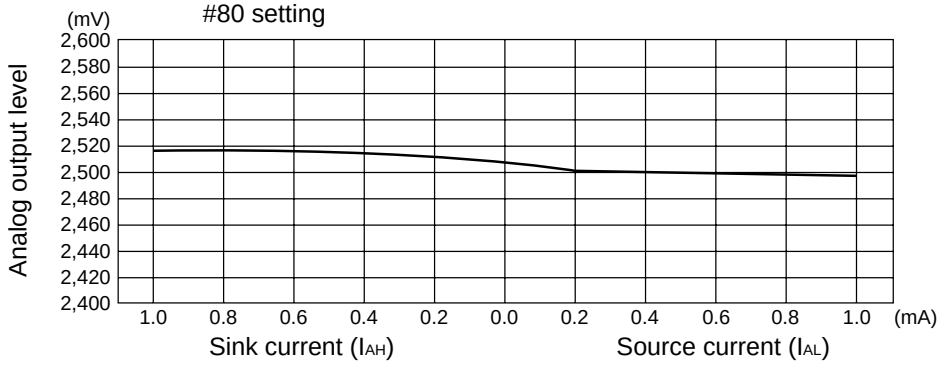


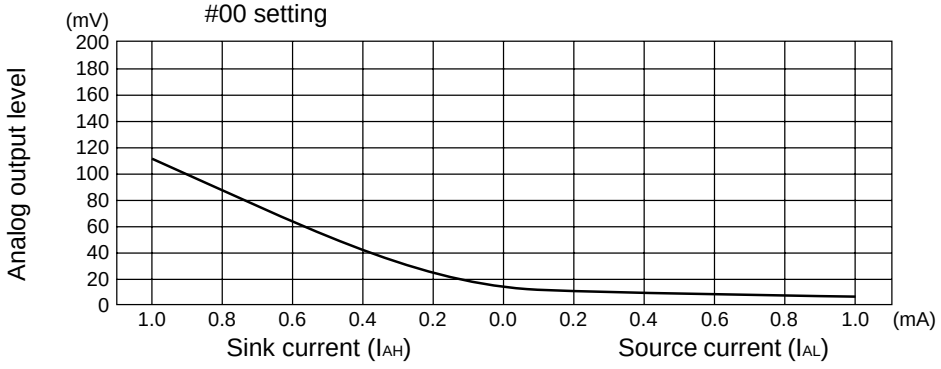

Note : The D/A output evaluation level is 90% and 10% of $V_{CC}$. The other evaluation level is 80% and 20% of $V_{CC}$.

## ■ EXAMPLE CHARACTERISTIC of $V_{AO}$ - $I_{AO}$





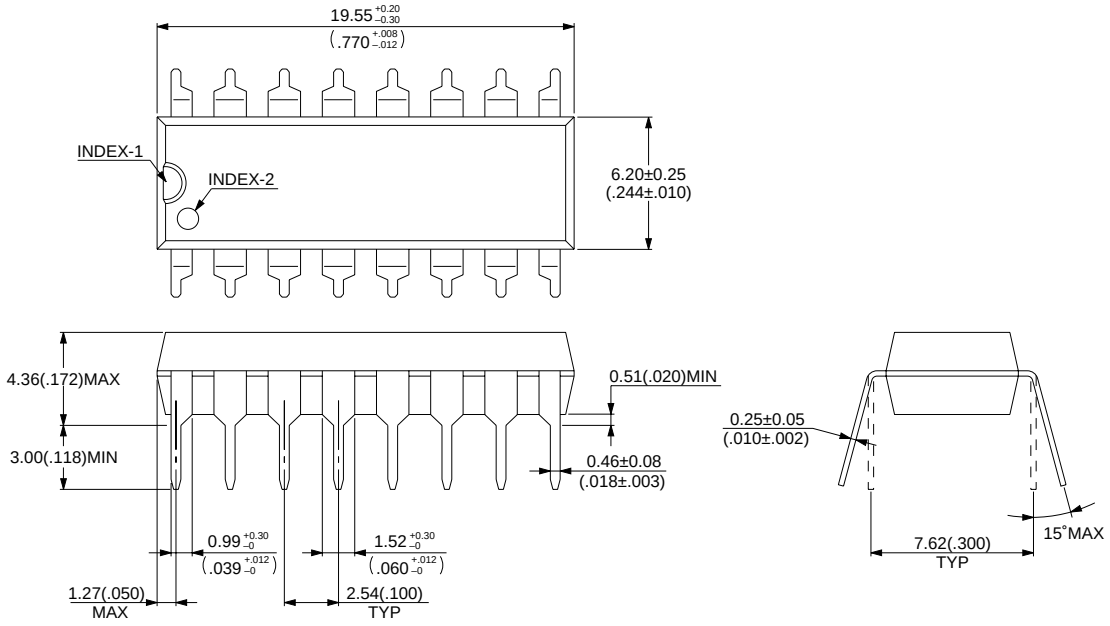



## ■ ORDERING INFORMATION

| Part No. | Package | Remarks |
|---|---|---|
| MB88347P | 16-pin plastic DIP (DIP-16P-M04) | |
| MB88347PF | 16-pin plastic SOP (FPT-16P-M06) | |
| MB88347PFV | 16-pin plastic SSOP (FPT-16P-M05) | |

## ■ PACKAGE DIMENSIONS

16-pin plastic DIP
(DIP-16P-M04)



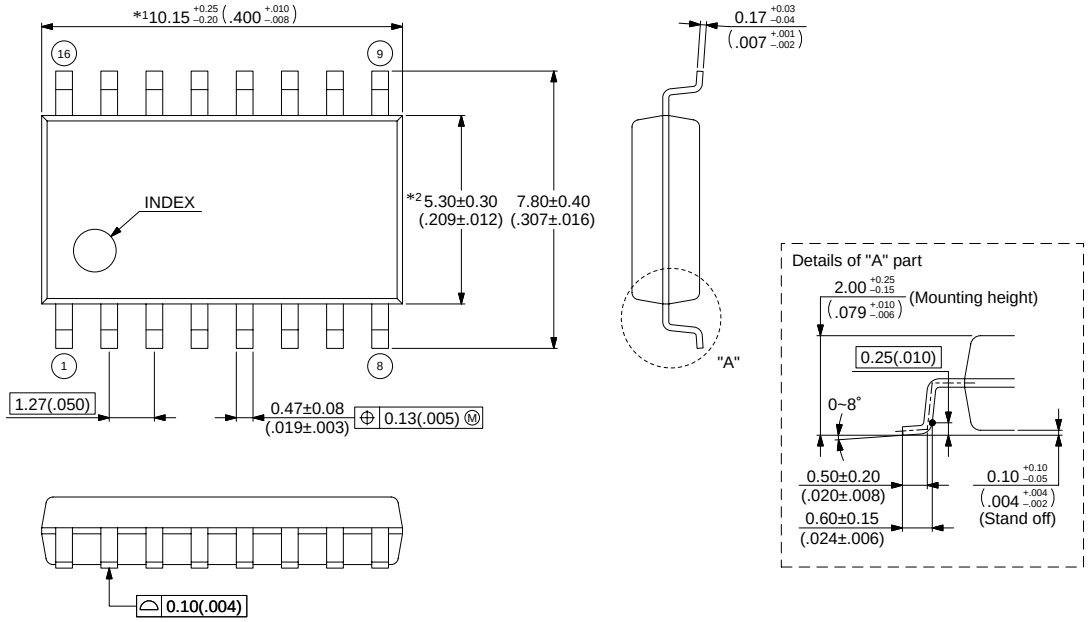



Dimensions in mm (inches).
Note : The values in parentheses are reference values.

*(Continued)*

16-pin plastic SOP
(FPT-16P-M06)

Note 1) *1 : These dimensions include resin protrusion.
Note 2) *2 : These dimensions do not include resin protrusion.
Note 3) Pins width and pins thickness include plating thickness.
Note 4) Pins width do not include tie bar cutting remainder.





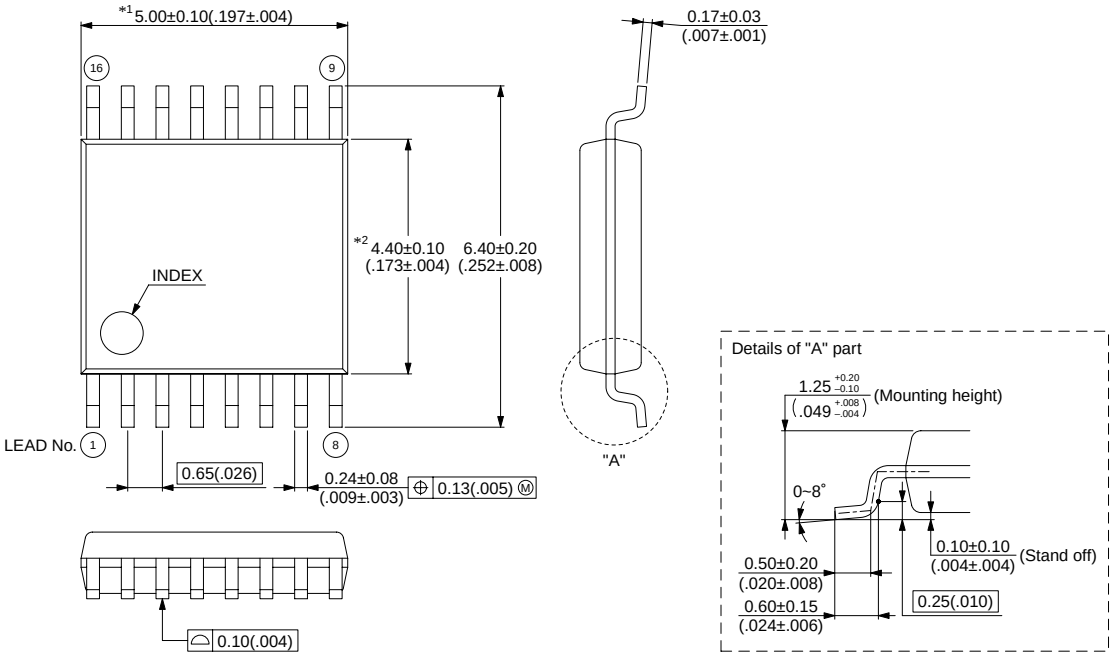

Dimensions in mm (inches).
Note: The values in parentheses are reference values.

*(Continued)*

*(Continued)*

16-pin plastic SSOP
(FPT-16P-M05)

Note 1) *1 : Resin protrusion. (Each side : +0.15 (.006) Max).
Note 2) *2 : These dimensions do not include resin protrusion.
Note 3) Pins width and pins thickness include plating thickness.
Note 4) Pins width do not include tie bar cutting remainder.






Dimensions in mm (inches).
Note: The values in parentheses are reference values.

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