

Linear IC converter

CMOS

D/A Converter for Digital Tuning (8-Channel, 8-bit, on-chip OP amp, low-voltage)

MB88347L

DESCRIPTION

The MB88347L incorporates eight 8-bit D/A converter modules. This device operates at low supply voltage in the performance guarantee range from 2.7 to 3.6 V. It also contains an output amplifier, allowing driving at large current.

Since the MB88347L inputs data in serial mode, it requires only three control lines for data input and two or more MB88347L units can be cascaded.

The MB88347L is function and pin compatible with the MB88347 (5-volt supply voltage model). The MB88347L can therefore easily replace the MB88347 in a system, thereby reducing the system's voltage requirement.

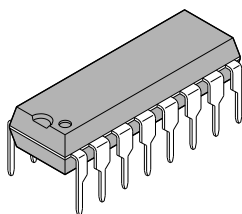
The MB88347L is the best replacement for electronic variable resistors or screwdriver control resistors.

FEATURES

- Ultra-low power consumption (0.5 mW/ch: typical)
- Low voltage operation ($V_{CC} = 2.7$ to 3.6 V)
- Ultra-compact space-saving package (SSOP-16)
- Contains 8-channel R-2R type 8-bit D/A converter
- On-chip analog output amps (sink current max. 1.0 mA, source current max. 1.0 mA)
- Analog output range from 0 V to V_{CC}
- Two separate power supply/ground lines for MCU interface block/operational amplifier output buffer block and D/A converter block
- Serial data input, maximum operating speed 2.5 MHz
- CMOS process
- Package lineup includes DIP 16-pin, SOP 16-pin, SSOP 16-pin

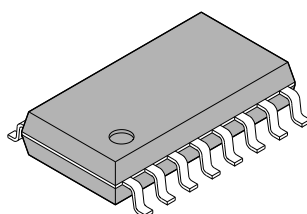
PACKAGES

16 pin, Plastic DIP



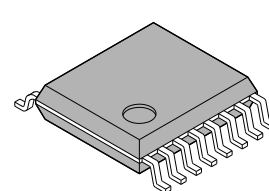
(DIP-16P-M04)

16 pin, Plastic SOP



(FPT-16P-M06)

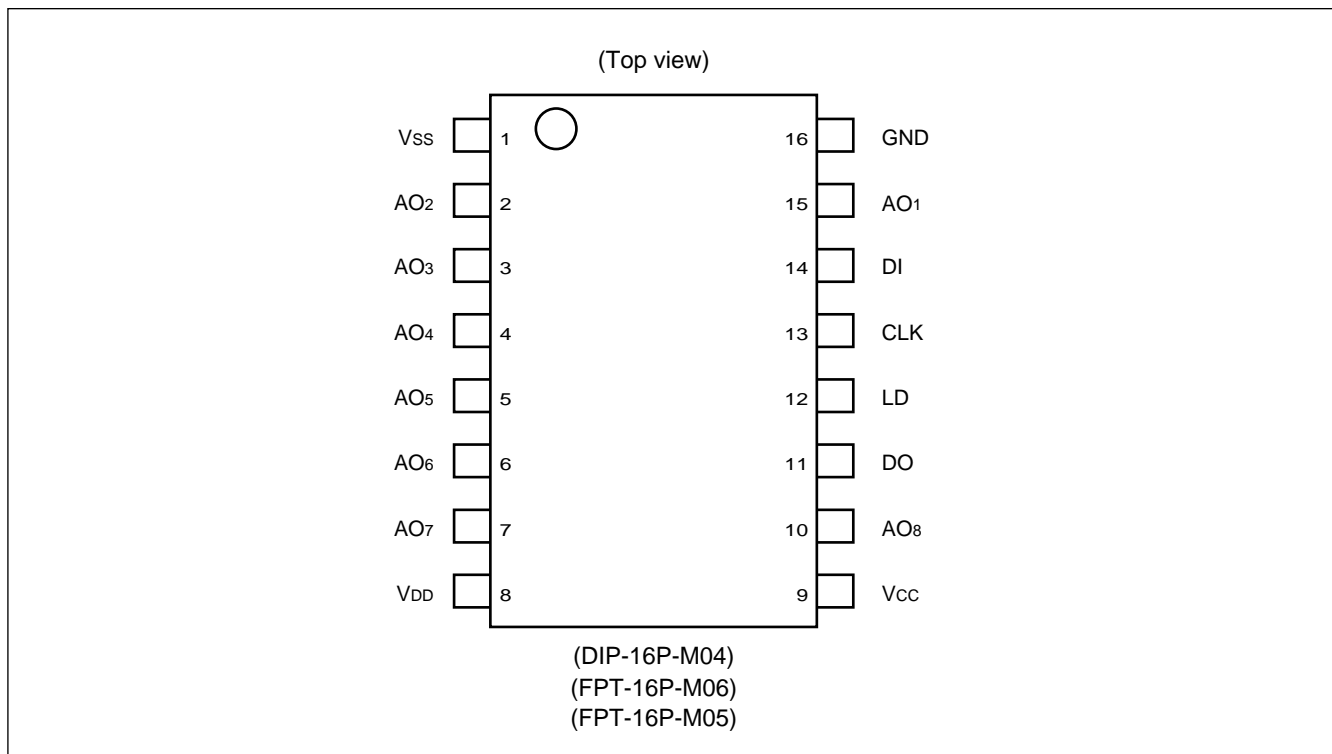
16 pin, Plastic SSOP



(FPT-16P-M05)

MB88347L

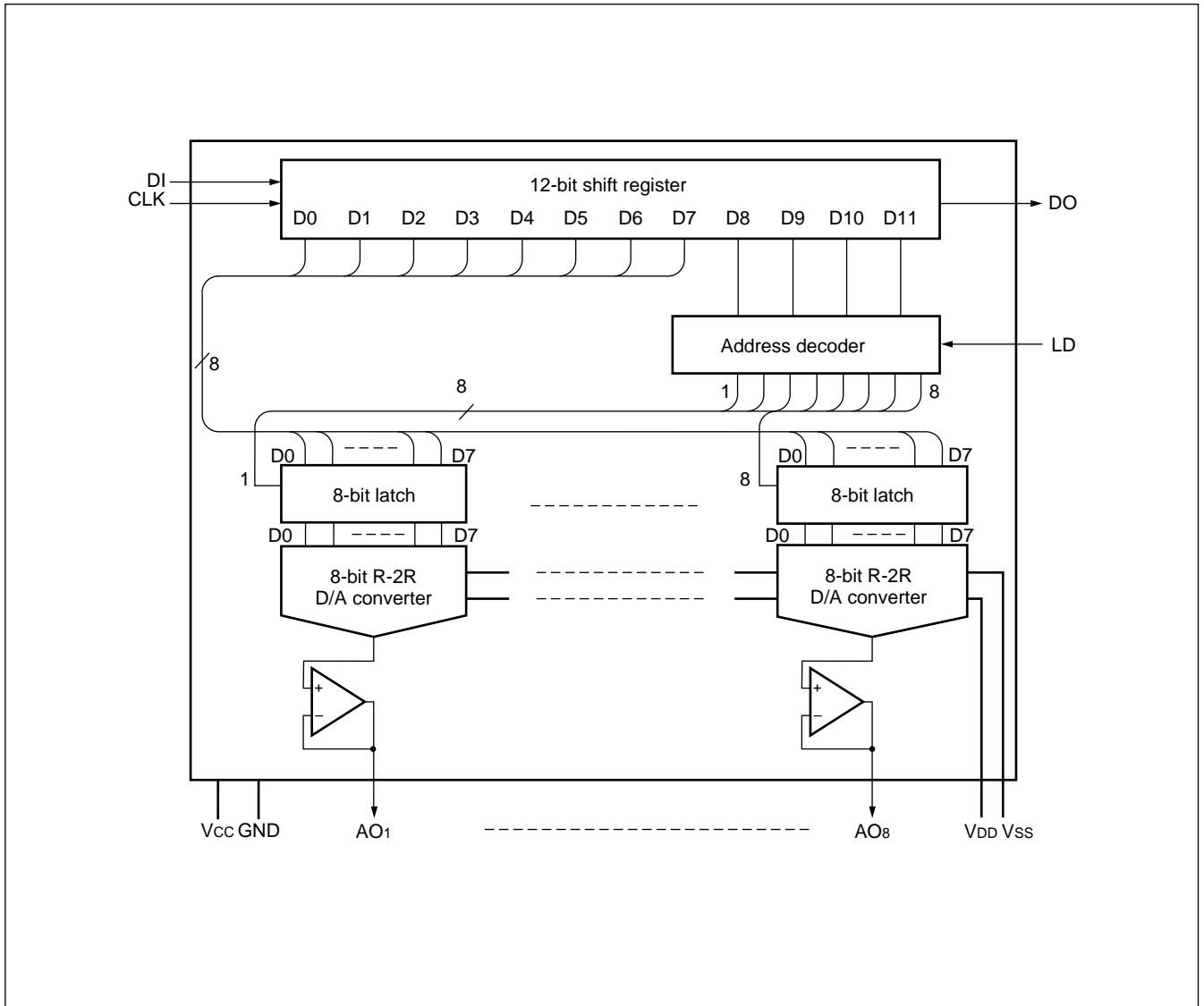
■ PIN ASSIGNMENT



■ PIN DESCRIPTION

| Pin No. | Pin name | I/O | Functions |
|----------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 14 | DI | I | Serial data input pin. This pin inputs serial data with a data length of 12 bits. (Do not leave the pin floating.) |
| 11 | DO | O | This pin outputs the MSB data in the 12-bit shift register at the CLK falling edge. |
| 13 | CLK | I | Shift clock input pin. The input signal from the DI pin enters the 12-bit shift register at the rising edge of the shift clock pulse. (Do not leave this pin floating.) |
| 12 | LD | I | When the LD pin inputs the High-level signal, shift register value is loaded to the decoder and the D/A output register. (Do not leave this pin floating. When data is not transferred, fix the pin to the "Low" level.) |
| 15 2 3 4 5 6 7 10 | AO ₁ AO ₂ AO ₃ AO ₄ AO ₅ AO ₆ AO ₇ AO ₈ | O | 8-bit D/A output with op amp. |
| 9 | V _{CC} | — | MCU interface and OP amp power-supply pin. |
| 16 | GND | — | MCU interface and OP amp GND pin. |
| 8 | V _{DD} | — | D/A converter reference power (High) input pin. |
| 1 | V _{SS} | — | D/A converter reference power (Low) input pin. |

■ **BLOCK DIAGRAM**



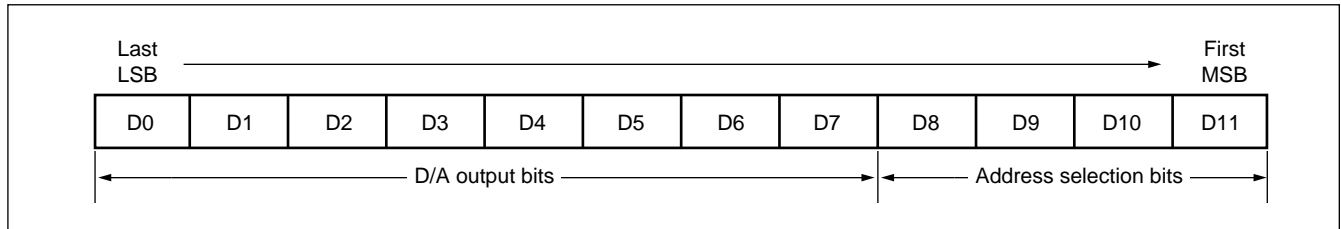
MB88347L

■ DATA CONFIGURATION

The MB88347L has a 12-bit shift register for chip control.

The 12-bit shift register must be used to set up data in the configuration shown below.

The data configuration has a total of 12 bits, for address selection and eight for D/A data output.



• D/A converter control signals

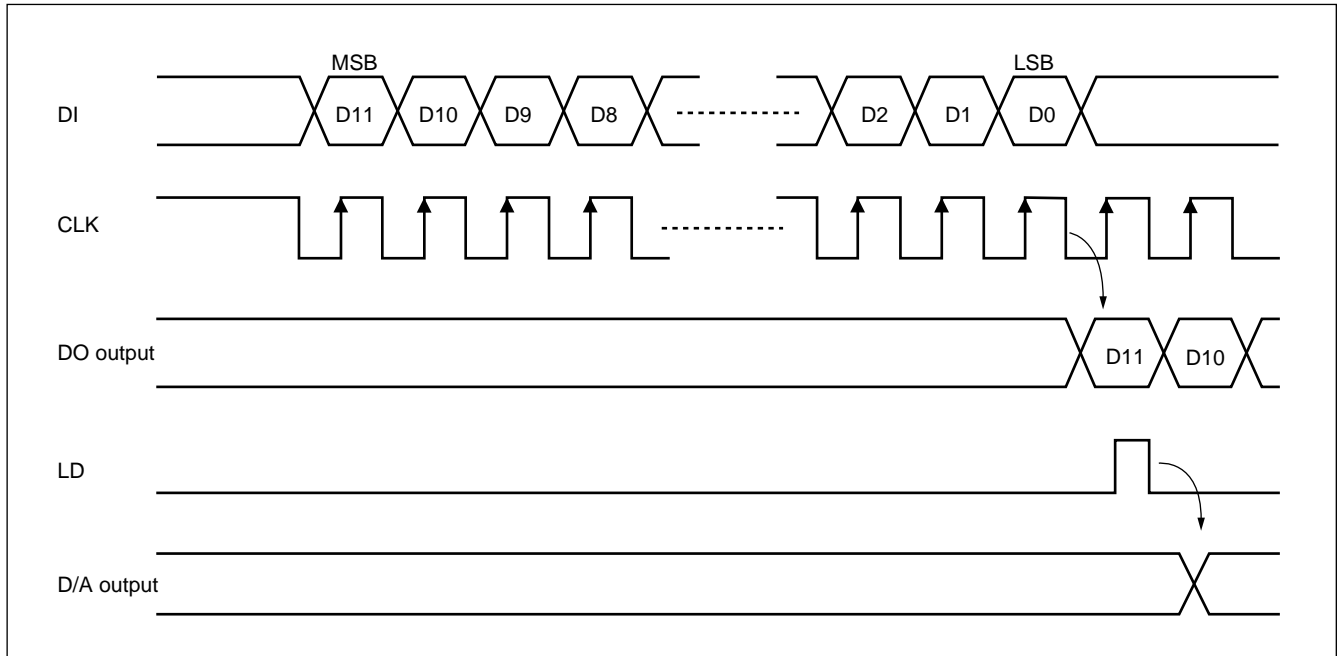
| D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D/A data output |
|----|----|----|----|----|----|----|----|------------------------------------|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | $\cong V_{SS}$ |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | $\cong V_{LB} \times 1 + V_{SS}$ |
| 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | $\cong V_{LB} \times 2 + V_{SS}$ |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | $\cong V_{LB} \times 254 + V_{SS}$ |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | $\cong V_{LB} \times 255 + V_{SS}$ |

Note: $V_{LB} = (V_{DD} - V_{SS})/256$

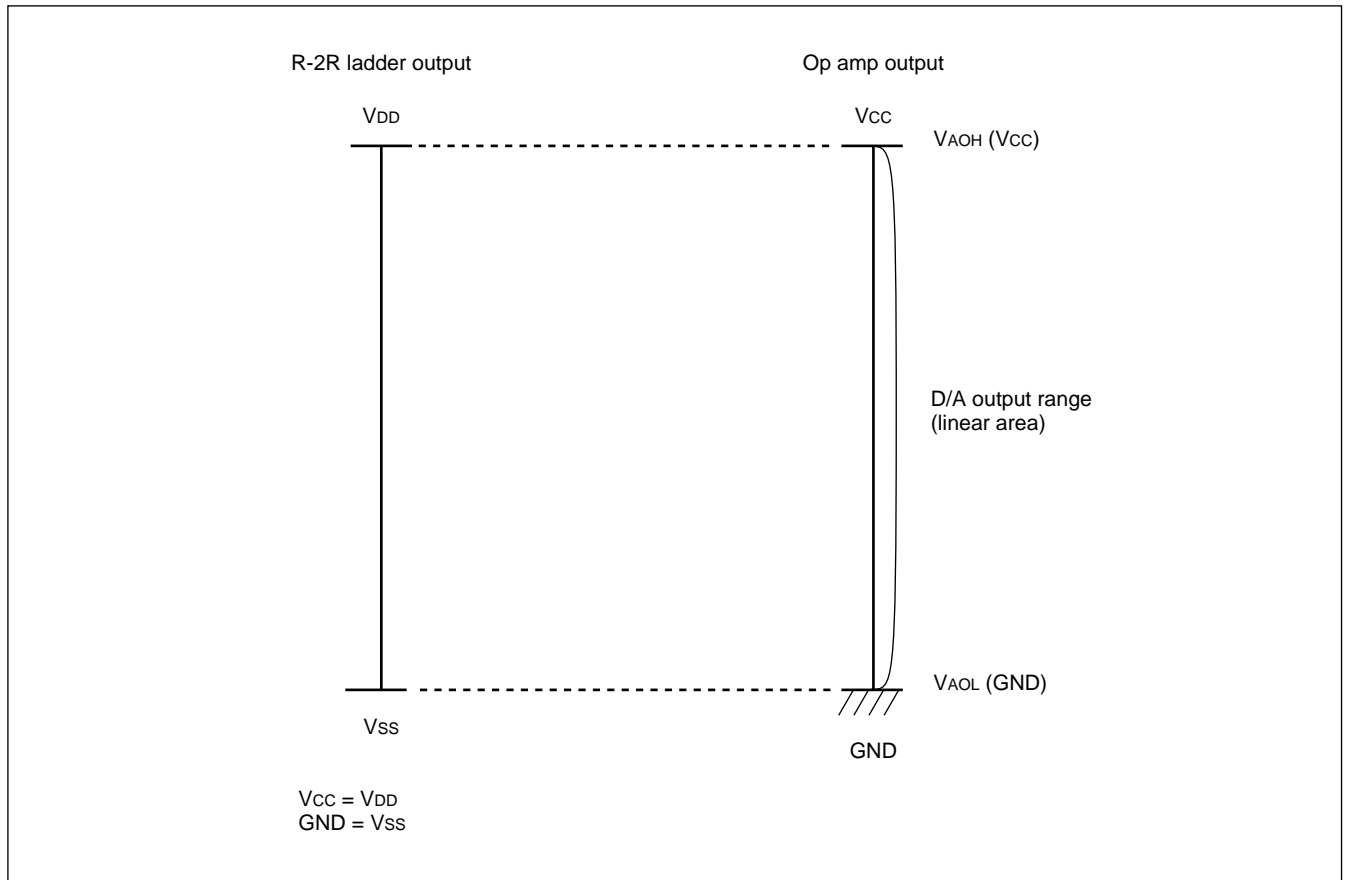
• Address selection signals

| D8 | D9 | D10 | D11 | Address selection |
|----|----|-----|-----|---------------------------|
| 0 | 0 | 0 | 0 | Don't Care |
| 0 | 0 | 0 | 1 | AO ₁ Selection |
| 0 | 0 | 1 | 0 | AO ₂ Selection |
| 0 | 0 | 1 | 1 | AO ₃ Selection |
| 0 | 1 | 0 | 0 | AO ₄ Selection |
| 0 | 1 | 0 | 1 | AO ₅ Selection |
| 0 | 1 | 1 | 0 | AO ₆ Selection |
| 0 | 1 | 1 | 1 | AO ₇ Selection |
| 1 | 0 | 0 | 0 | AO ₈ Selection |
| 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 |

■ DATA SETTING TIMING CHART



■ ANALOG OUTPUT VOLTAGE RANGE



MB88347L

■ ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Conditions | Rating | | Unit |
|-----------------------|------------------|----------------------------|--------|-----------------------|------|
| | | | Min. | Max. | |
| Supply voltage | V _{CC} | Based on GND Ta = +25°C | -0.3 | 5.0 | V |
| | V _{DD} | | -0.3* | 5.0* | 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 | — | -20 | +85 | °C |
| Storage temperature | Tstg | — | -55 | +150 | °C |

* : V_{CC} ≥ 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 | Conditions | Rating | | Unit |
|-----------------------------------|-----------------|-------------------------------------------|------------|-----------------------|------|
| | | | Min. | Max. | |
| Power supply voltage 1 | V _{CC} | — | 2.7 | 3.6 | V |
| | GND | — | Typical: 0 | | V |
| Power supply voltage 2 | V _{DD} | V _{DD} - V _{SS} ≥ 2.0 V | 2.0 | V _{CC} | V |
| | V _{SS} | | GND | V _{CC} - 2.0 | V |
| Analog output source current | I _{AL} | V _{CC} = 3.0 V | — | 1.0 | mA |
| Analog output sink current | I _{AH} | V _{CC} = 3.0 V | — | 1.0 | mA |
| Oscillation limit output capacity | C _{OL} | — | — | 1.0 | μF |
| Digital data value range | — | — | #00 | #FF | — |
| Operating temperature | Ta | — | -20 | +85 | °C |

WARNING: Recommended operating conditions are normal operating ranges for the semiconductor device. All the device's electrical characteristics are warranted when operated within these ranges.

Always use semiconductor devices within the recommended operating conditions. 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 representative beforehand.

■ ELECTRICAL CHARACTERISTICS

1. DC Characteristics

(1) Digital block

($V_{DD}, V_{CC} = 2.7\text{ V to }3.6\text{ V}$ ($V_{CC} \geq V_{DD}$), $GND, V_{SS} = 0\text{ V}$, $T_a = -20^\circ\text{C to }+85^\circ\text{C}$)

| Parameter | Symbol | Pin name | Conditions | Value | | | Unit |
|------------------------|-----------|-----------------|-----------------------------------------------|----------------|------|--------------|------|
| | | | | Min. | Typ. | Max. | |
| Power supply voltage | V_{CC} | V_{CC} | — | 2.7 | 3.0 | 3.6 | V |
| Power supply current 1 | I_{CC} | | Operation at CLK = 1 MHz (with no load) | — | 0.8 | 2.0 | mA |
| Input leak current | I_{ILK} | CLK DI LD | $V_{IN} = 0\text{ V to }V_{CC}$ | -10 | — | 10 | mA |
| L level input voltage | V_{IL} | | — | — | — | $0.2 V_{CC}$ | V |
| H level input voltage | V_{IH} | | — | $0.8 V_{CC}$ | — | — | V |
| L level output voltage | V_{OL} | DO | $I_{OL} = 2.5\text{ mA}$ | — | — | 0.4 | V |
| H level output voltage | V_{OH} | | $I_{OH} = -400\text{ mA}$ | $V_{CC} - 0.4$ | — | — | V |

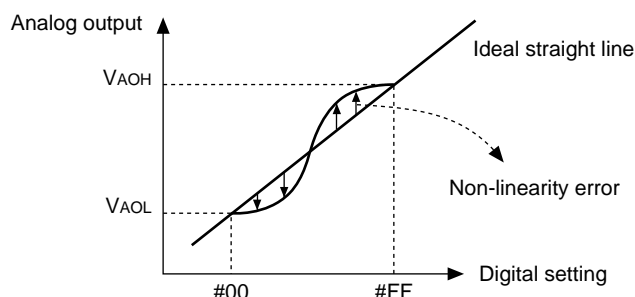
(2) Analog block (1)

($V_{DD}, V_{CC} = 2.7\text{ V to }3.6\text{ V}$ ($V_{CC} \geq V_{DD}$), $GND, V_{SS} = 0\text{ V}$, $T_a = -20^\circ\text{C to }+85^\circ\text{C}$)

| Parameter | Symbol | Pin name | Conditions | Value | | | Unit |
|--------------------------------|----------|------------------------------------|------------------------------------------------------------------------------|-------|------|----------------|------|
| | | | | Min. | Typ. | Max. | |
| Power consumption | I_{DD} | V_{DD} | No load | — | 0.6 | 1.0 | mA |
| Analog voltage | V_{DD} | V_{DD} | $V_{DD} - V_{SS} \geq 2.0\text{ V}$ | 2.0 | — | V_{CC} | V |
| | V_{SS} | V_{SS} | | GND | — | $V_{CC} - 2.0$ | V |
| Resolution | Res | AO ₁ to AO ₈ | — | — | 8 | — | bits |
| Monotonic increase | Rem | | — | — | 8 | — | bits |
| Non-linearity error*1 | LE | | No load $V_{DD} \leq V_{CC} - 0.1\text{ V}$ $V_{SS} \geq 0.1\text{ V}$ | -1.5 | — | 1.5 | LSB |
| Differential linearity error*2 | DLE | | — | -1.0 | — | 1.0 | LSB |

*1: Deviation (error) in input/output curves with respect to an ideal straight line connecting output voltage at "00" and output voltage at "FF"

*2: Deviation (error) in amplification with respect to theoretical increase in amplification per 1-bit increase in digital value.



Note: The value of V_{AOH} and V_{DD} , and the value of V_{AOL} and V_{SS} are not necessarily equivalent.

MB88347L

(3) Analog section (2)

(Ta = -20°C to +85°C)

| Parameter | Symbol | Pin name | Conditions | Values | | | Unit |
|--------------------------|-------------------|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------|-----------------------|------|
| | | | | Min. | Typ. | Max. | |
| Output minimum voltage 1 | V _{AOL1} | AO ₁ to AO ₈ | V _{DD} = V _{CC} = 3.0 V V _{SS} = GND = 0.0 V I _{AL} = 0 μA Digital data = #00 | V _{SS} | — | V _{SS} + 0.1 | V |
| Output minimum voltage 2 | V _{AOL2} | | V _{DD} = V _{CC} = 3.0 V V _{SS} = GND = 0.0 V I _{AL} = 500 μA Digital data = #00 | V _{SS} - 0.2 | V _{SS} | V _{SS} + 0.2 | V |
| Output minimum voltage 3 | V _{AOL3} | | V _{DD} = V _{CC} = 3.0 V V _{SS} = GND = 0.0 V I _{AH} = 500 μA Digital data = #00 | V _{SS} | — | V _{SS} + 0.2 | V |
| Output minimum voltage 4 | V _{AOL4} | | V _{DD} = V _{CC} = 3.0 V V _{SS} = GND = 0.0 V I _{AL} = 1.0 mA Digital data = #00 | V _{SS} - 0.3 | V _{SS} | V _{SS} + 0.3 | V |
| Output minimum voltage 5 | V _{AOL5} | | V _{DD} = V _{CC} = 3.0 V V _{SS} = GND = 0.0 V I _{AH} = 1.0 mA Digital data = #00 | V _{SS} | — | V _{SS} + 0.3 | V |
| Output maximum voltage 1 | V _{AOH1} | | V _{DD} = V _{CC} = 3.0 V V _{SS} = GND = 0.0 V I _{AL} = 0 μA Digital data = #FF | V _{DD} - 0.1 | — | V _{DD} | V |
| Output maximum voltage 2 | V _{AOH2} | | V _{DD} = V _{CC} = 3.0 V V _{SS} = GND = 0.0 V I _{AL} = 500 μA Digital data = #FF | V _{DD} - 0.2 | — | V _{DD} | V |
| Output maximum voltage 3 | V _{AOH3} | | V _{DD} = V _{CC} = 3.0 V V _{SS} = GND = 0.0 V I _{AH} = 500 μA Digital data = #FF | V _{DD} - 0.2 | V _{DD} | V _{SS} + 0.2 | V |
| Output maximum voltage 4 | V _{AOH4} | | V _{DD} = V _{CC} = 3.0 V V _{SS} = GND = 0.0 V I _{AL} = 1.0 mA Digital data = #FF | V _{DD} - 0.3 | — | V _{DD} | V |
| Output maximum voltage 5 | V _{AOH5} | | V _{DD} = V _{CC} = 3.0 V V _{SS} = GND = 0.0 V I _{AH} = 1.0 mA Digital data = #FF | V _{DD} - 0.3 | V _{DD} | V _{SS} + 0.3 | V |

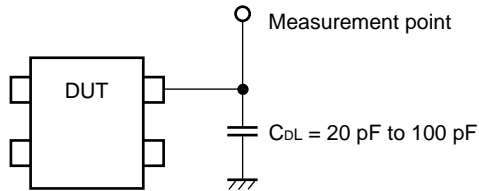
2. AC Characteristics

($V_{DD}, V_{CC} = 2.7\text{ V to }3.6\text{ V}$ ($V_{CC} \geq V_{DD}$), $GND, V_{SS} = 0\text{ V}$, $T_a = -20^\circ\text{C to }+85^\circ\text{C}$)

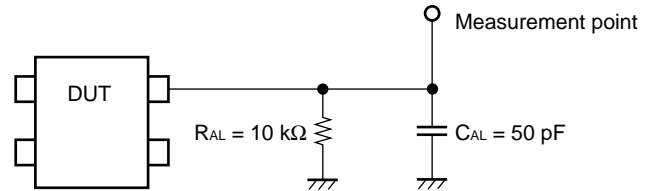
| Parameter | Symbol | Conditions | Rating | | Unit |
|------------------------------------|------------------------------------|----------------------------|--------|------|------|
| | | | Min. | Max. | |
| Clock L level pulse width | t _{CLK} | — | 200 | — | ns |
| Clock H level pulse width | t _{CKH} | — | 200 | — | ns |
| Clock rise time Clock fall time | t _{cr} 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 |
| Load H level pulse width | t _{LDH} | — | 100 | — | ns |
| Data output delay time | t _{DO} | See “Load conditions (1).” | — | 170 | ns |
| D/A output settling time | t _{LDD} | See “Load conditions (2).” | — | 200 | μs |

Load conditions

- Load conditions (1)

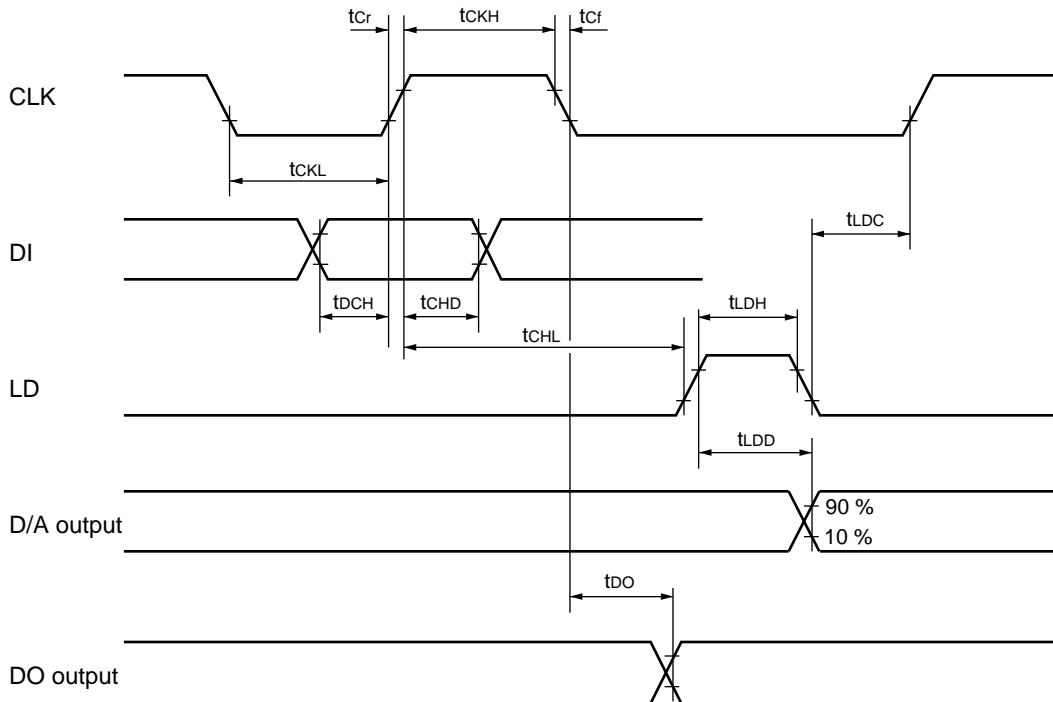


- Load conditions (2)



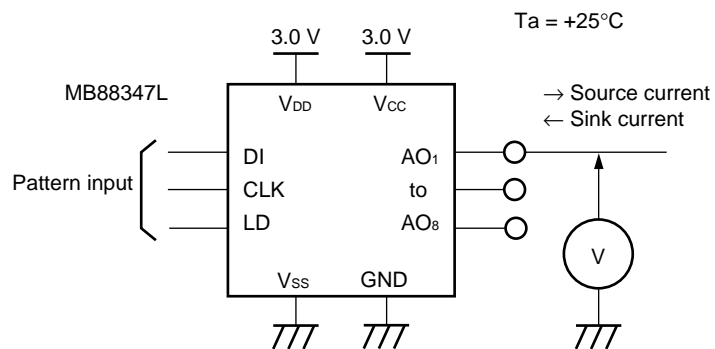
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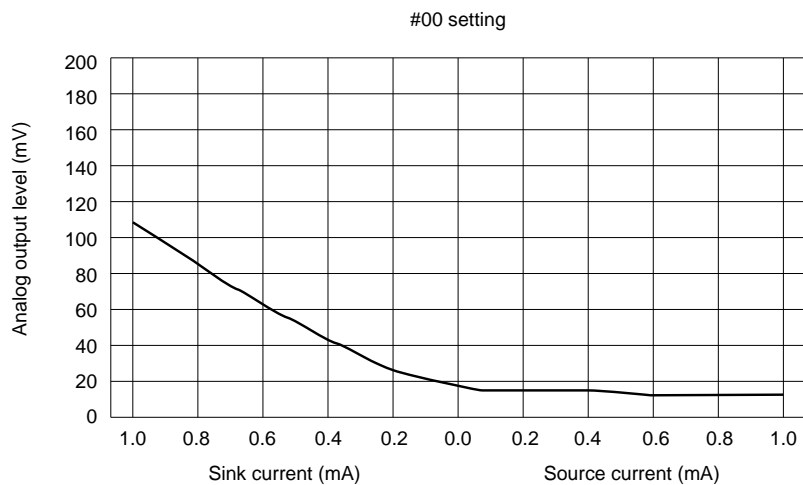
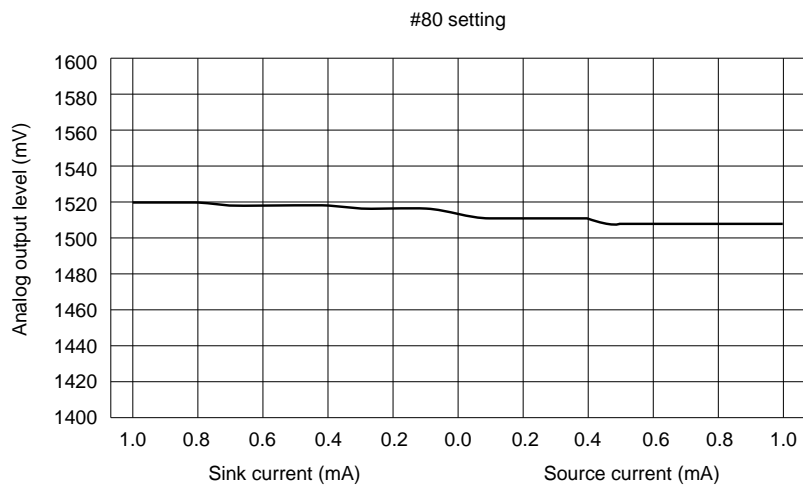
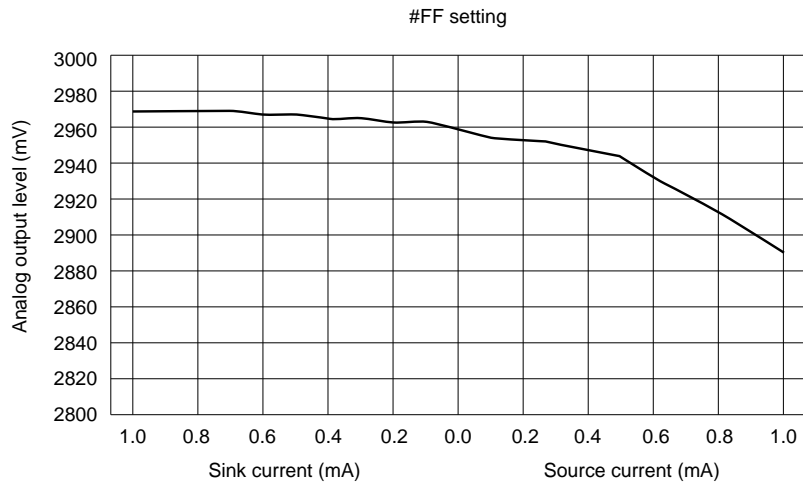
Input/output timing



Note: Evaluation levels are 80% and 20% of V_{CC} .

■ V_{AO} vs. I_{AO} CHARACTERISTICS: EXAMPLE





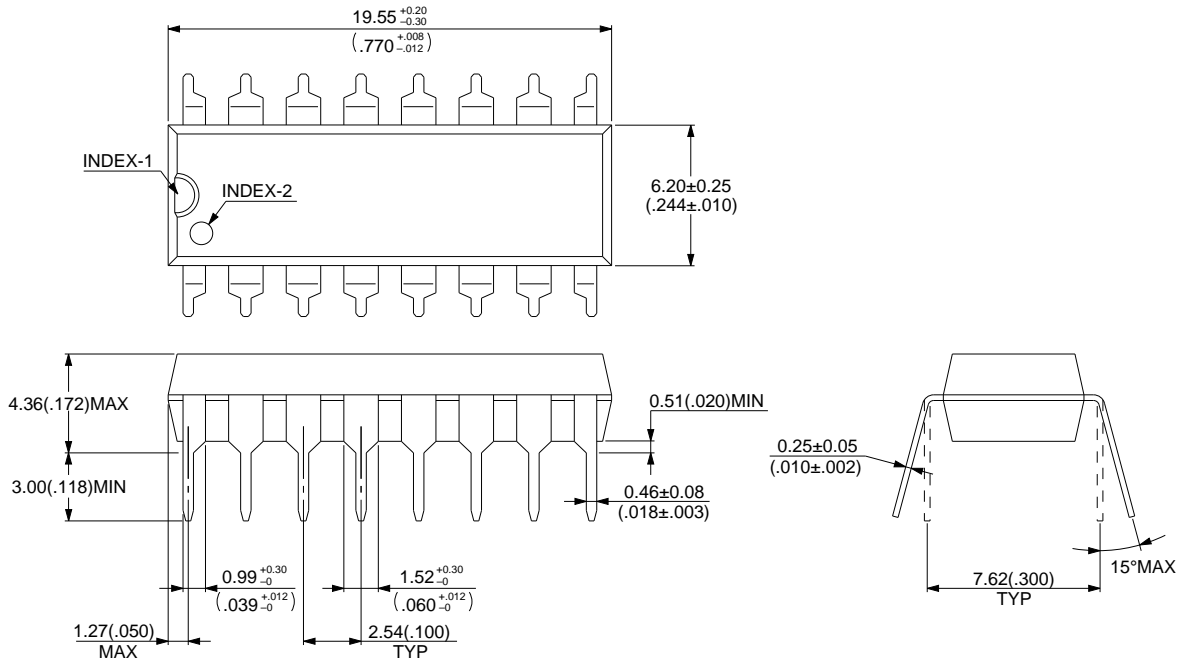
MB88347L

■ ORDERING INFORMATION

| Part number | Package | Remarks |
|-------------|---------------------------------------|---------|
| MB88347LP | 16 pin, Plastic DIP (DIP-16P-M04) | |
| MB88347LPF | 16 pin, Plastic SOP (FPT-16P-M06) | |
| MB88347LPFV | 16 pin, Plastic SSOP (FPT-16P-M05) | |

■ PACKAGE DIMENSIONS

16 pin, Plastic DIP
 (DIP-16P-M04)



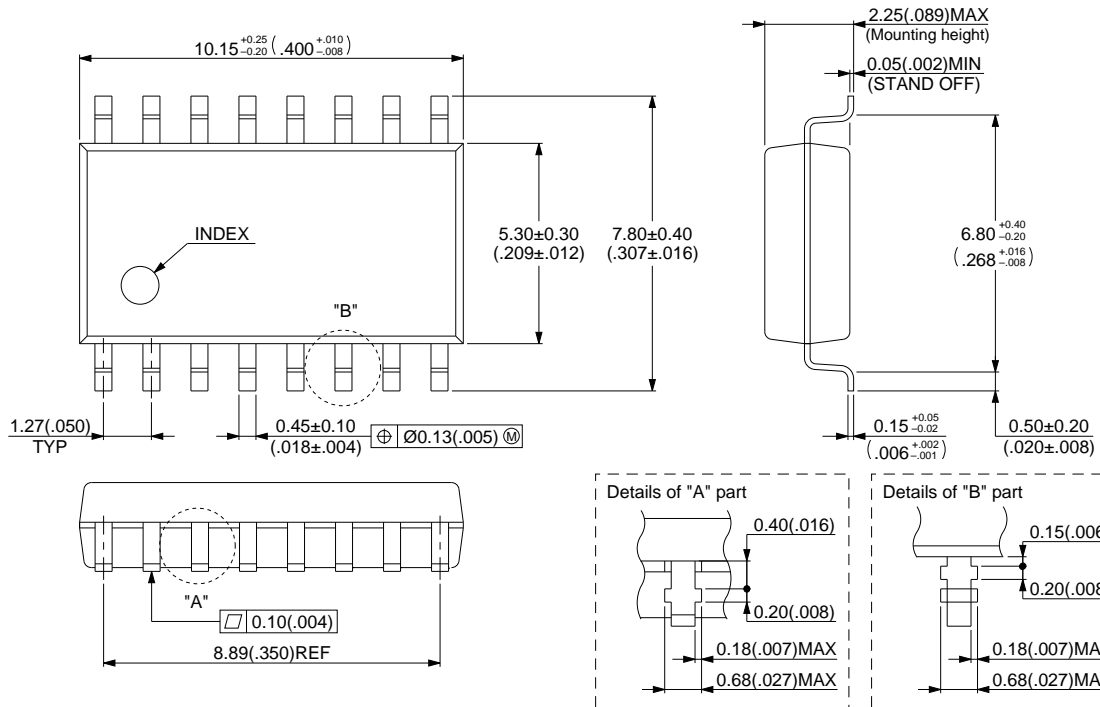
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Dimensions in mm (inches).

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MB88347L

16 pin, Plastic SOP
(FPT-16P-M06)



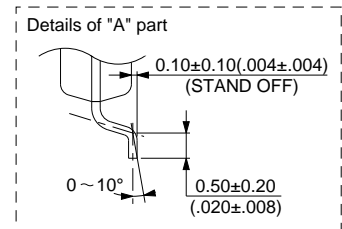
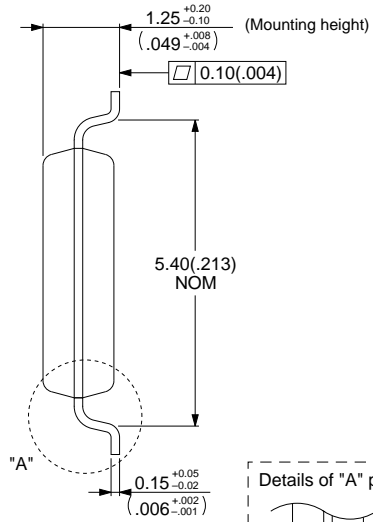
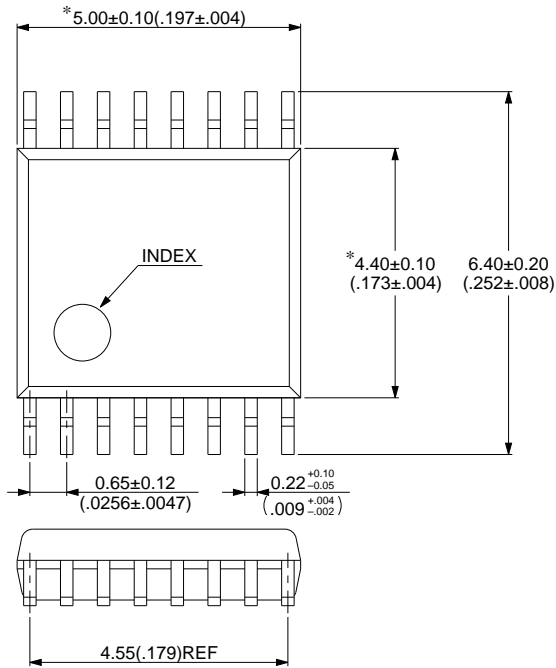
Dimensions in mm (inches).

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16 pin, Plastic SSOP
 (FPT-16P-M05)

*: This dimension does not include resin protrusion.



MB88347L

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