FUJITSU MICROELECTRONICS
DATA SHEET

DS04-13511-3Ea

*Linear IC Converter*

**CMOS**

# D/A Converter for Digital Tuning

**(12-channel, 8-bit, on-chip OP amp, low-voltage)**

# MB88346L

## ■ DESCRIPTION

The Fujitsu Microelectronics MB88346L is a 12-channel 8-bit D/A converter capable of low-voltage operation that has amplifiers built into each of the 12 analog output lines to deliver heavy-current drive capability.

The use of serial data input means that only three control lines are required, and enables cascade connection of multiple MB88346L chips.

The MB88346L is suitable for applications such as electronic volume controls and replacing trimmer potentiometers in tuning systems. In addition, the MB88346L is both function-compatible and pin-compatible the currently used MB88346B, making it easy to reduce the voltage level of a system by simply replacing the MB88346B with the MB88346L.

## ■ FEATURES

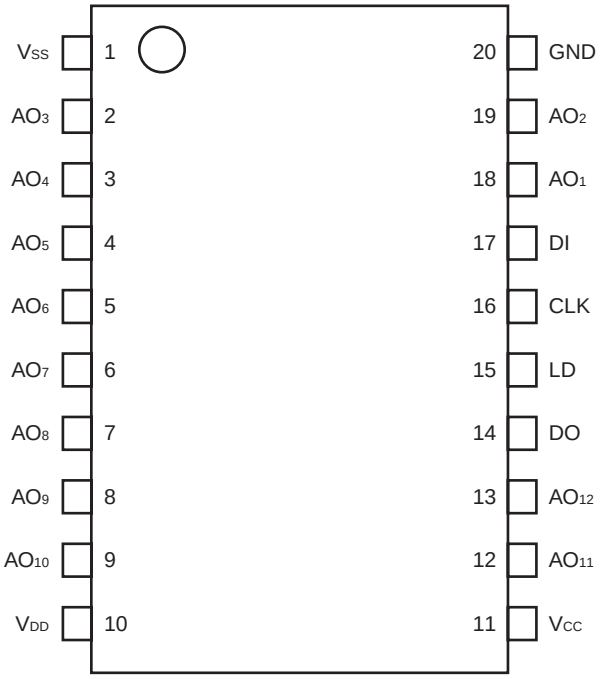
- Low voltage operation ($V_{CC}$/$V_{DD}$ : 2.7 V to 3.6 V)
- Ultra-low power consumption (0.5 mW/ch at $V_{CC}$ = 3 V)
- Ultra-compact space-saving package lineup (SSOP-20)
- Contains 12-channel R-2R type 8-bit D/A converter
- On-chip analog output amps (sink current max. 1.0 mA, source current max. 1.0 mA)
- Analog output range from 0 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
  (maximum operating speed in cascade connection is 1.5 MHz)
- CMOS process
- Package lineup includes DIP 20-pin, SSOP 20-pin

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## ■ PIN ASSIGNMENT

(Top view)

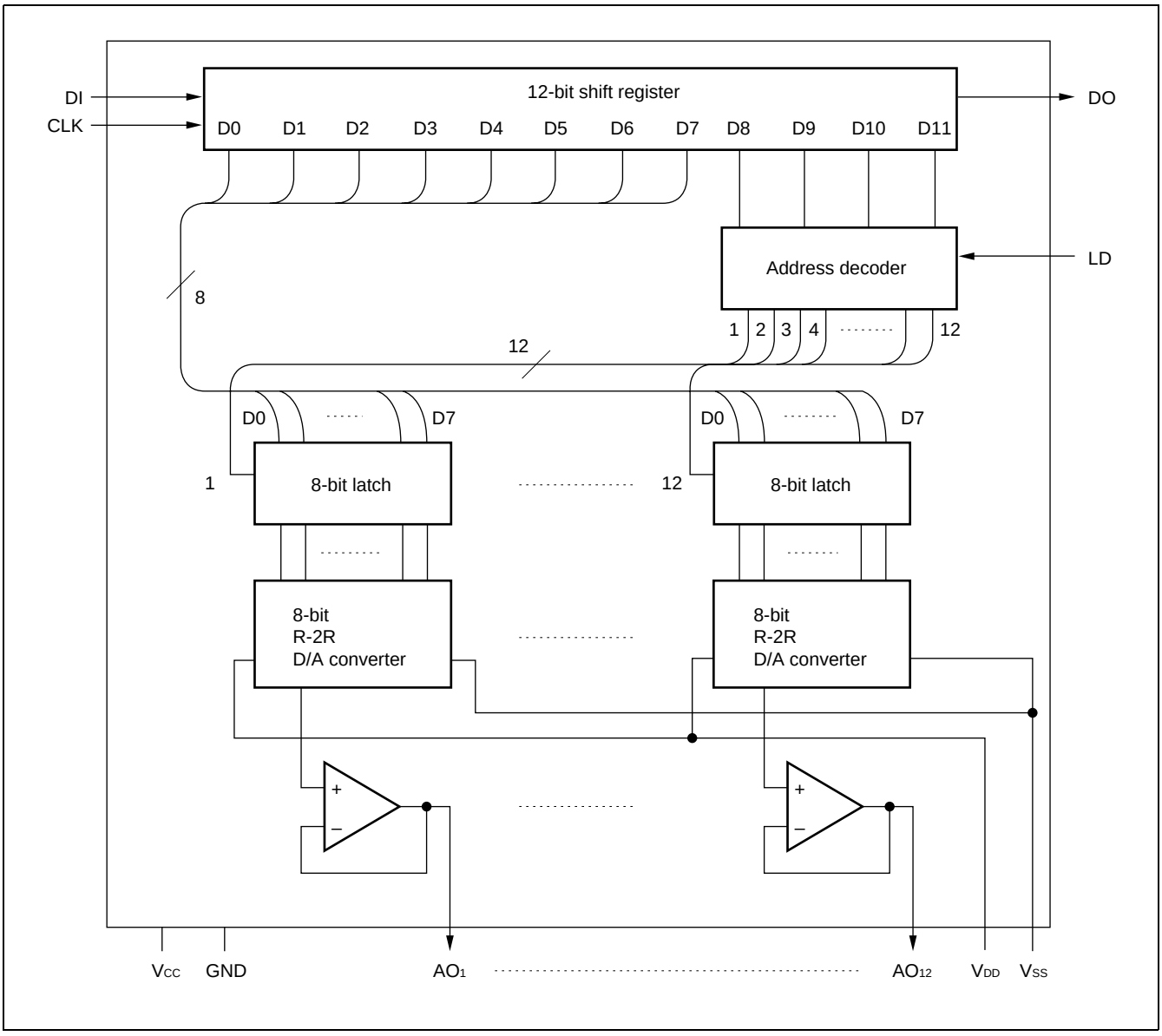



(DIP-20P-M02)
(FPT-20P-M03)

## ■ PIN DESCRIPTION

| Pin No. | Symbol | I/O | Function |
|---|---|---|---|
| 17 | DI | I | Serial address/data input to the internal 12-bit shift register : The address/data format is that upper 4 bits (D11 to D8) indicate an address and lower 8 bits (D7 to D0) indicate data. The D11 (MSB) is the first-in bit and D0 (LSB) is the last-in bit. |
| 14 | DO | O | Outputs MSB bit data from 12-bit shift register. |
| 16 | CLK | I | Shift clock input to the internal 12-bit shift register : At the rising edge of CLK data on the DI pin is shifted into the LSB of the shift register and contents of the shift register are shifted right (to the MSB) . |
| 15 | LD | I | Load strobe input for a 12-bit address/data : A high level on the LD pin latches a 4-bit address (upper 4 bits : D11 to D8) of the internal 12-bit shift register into the internal address decoder, and writes 8-bit data (lower 8 bits : D7 to D0) of the shift register into an internal data latch selected by the latched address. |
| 18<br>19<br>2<br>3<br>4<br>5<br>6<br>7<br>8<br>9<br>12<br>13 | $AO_1$<br>$AO_2$<br>$AO_3$<br>$AO_4$<br>$AO_5$<br>$AO_6$<br>$AO_7$<br>$AO_8$<br>$AO_9$<br>$AO_{10}$<br>$AO_{11}$<br>$AO_{12}$ | O | 8-bit D/A output pins with OP amps. |
| 11 | $V_{CC}$ | — | MCU interface and OP amp power supply pin. |
| 20 | GND | — | MCU interface and OP amp ground pin. |
| 10 | $V_{DD}$ | — | D/A converter power supply pin. |
| 1 | $V_{SS}$ | — | D/A converter ground pin. |

## ■ BLOCK DIAGRAM

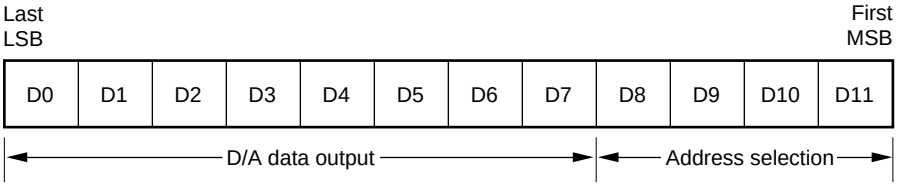


## ■ DATA CONFIGURATION

The MB88346L has a 12-bit shift register for controlling the chip. The data passed to the 12-bit shift register needs to be supplied in the following format.

The data structure consists of a total of 12 bits, four for address selection and eight for D/A data output.

### 1. Shift Register Control Data Configuration




### 2. 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 | $\fallingdotseq V_{SS}$ |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | $\fallingdotseq V_{LB} + V_{SS}$ |
| 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | $\fallingdotseq V_{LB} \times 2 + V_{SS}$ |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | $\fallingdotseq V_{LB} \times 254 + V_{SS}$ |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | $\fallingdotseq V_{DD}$ |

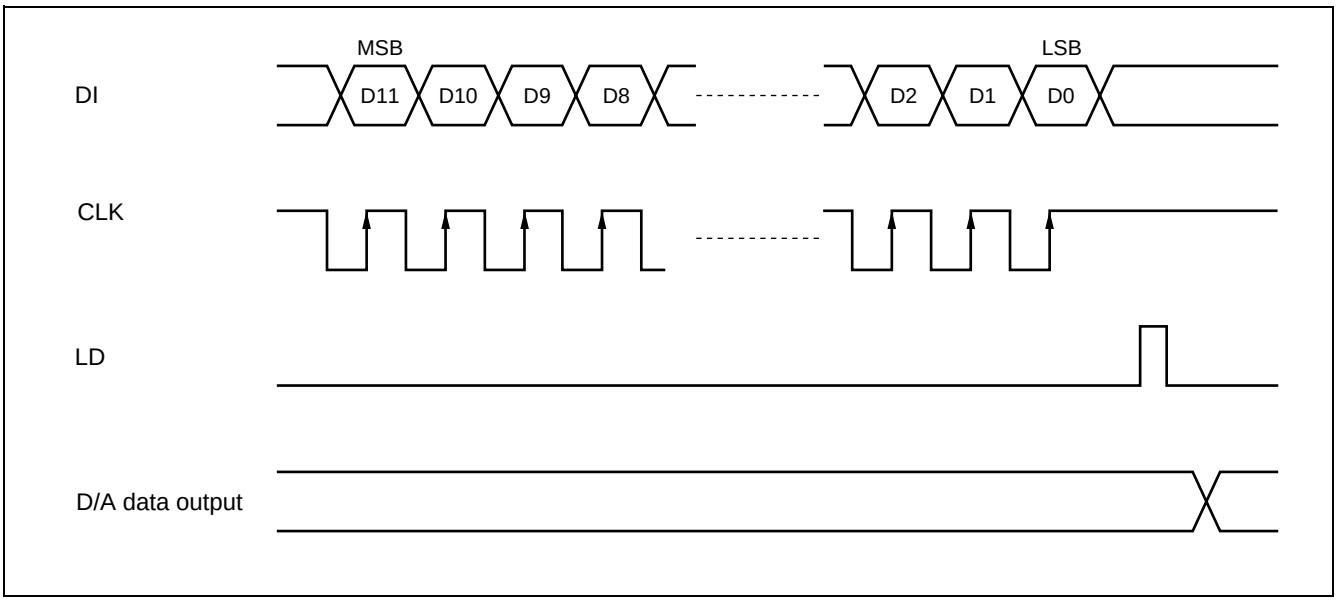
$V_{LB} = (V_{DD} - V_{SS}) / 255$

### 3. Address Selection Signals

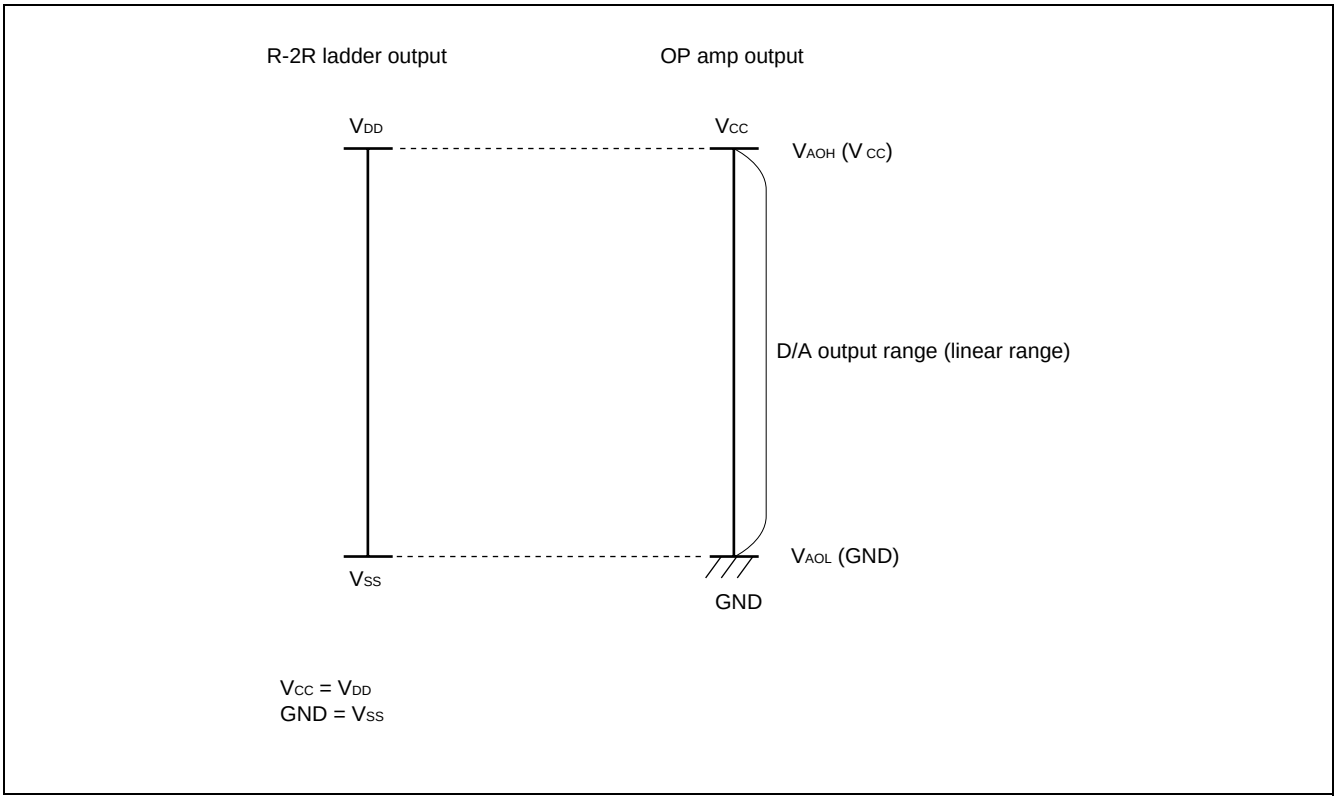
| D8 | D9 | D10 | D11 | Address selection |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | Don't Care |
| 0 | 0 | 0 | 1 | $AO_1$ selection |
| 0 | 0 | 1 | 0 | $AO_2$ selection |
| 0 | 0 | 1 | 1 | $AO_3$ selection |
| 0 | 1 | 0 | 0 | $AO_4$ selection |
| 0 | 1 | 0 | 1 | $AO_5$ selection |
| 0 | 1 | 1 | 0 | $AO_6$ selection |
| 0 | 1 | 1 | 1 | $AO_7$ selection |
| 1 | 0 | 0 | 0 | $AO_8$ selection |
| 1 | 0 | 0 | 1 | $AO_9$ selection |
| 1 | 0 | 1 | 0 | $AO_{10}$ selection |
| 1 | 0 | 1 | 1 | $AO_{11}$ selection |
| 1 | 1 | 0 | 0 | $AO_{12}$ selection |
| 1 | 1 | 0 | 1 | Don't Care |
| 1 | 1 | 1 | 0 | Don't Care |
| 1 | 1 | 1 | 1 | Don't Care |

## ■ OPERATING DESCRIPTION

### 1. Timing Chart for Data Condition Setup




### 2. Analog Output Voltage Range



## ■ ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Condition | Rating | | Unit |
|---|---|---|---|---|---|
| | | | Min | Max | |
| Power supply voltage | $V_{CC}$ | GND used as reference, 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 | — | − 20 | + 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 | Typ | Max | |
| Power supply voltage 1 | $V_{CC}$ | — | 2.7 | — | 3.6 | 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 | $I_{AL}$ | $V_{CC}$ = 3.0 V | — | — | 1.0 | mA |
| Analog output sink current | $I_{AH}$ | $V_{CC}$ = 3.0 V | — | — | 1.0 | mA |
| Oscillator limiting output capacity | $C_{AL}$ | — | — | — | 0.1 | μF |
| Digital data value range | — | — | #00 | — | #FF | — |
| Operating temperature | Ta | — | − 20 | — | + 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 representatives beforehand.

## ■ ELECTRICAL CHARACTERISTICS

### 1. DC Characteristics

#### (1) Digital Block

($V_{DD}$, $V_{CC}$ = 2.7 V to 3.6 V ($V_{CC} \geq V_{DD}$) , GND = $V_{SS}$ = 0 V, Ta = –20 °C to +85 °C)

| Parameter | Symbol | Pin | Condition | Value | | | Unit |
|---|---|---|---|---|---|---|---|
| | | | | Min | Typ | Max | |
| Power supply voltage | $V_{CC}$ | $V_{CC}$ | — | 2.7 | 3.0 | 3.6 | V |
| Power supply current 1 | $I_{CC}$ | | Stationary (CLK signal stopped) , no load | — | 1.2 | 3.0 | mA |
| Input leak 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 | $V_{IH}$ | | — | 0.8 $V_{CC}$ | — | — | 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 |

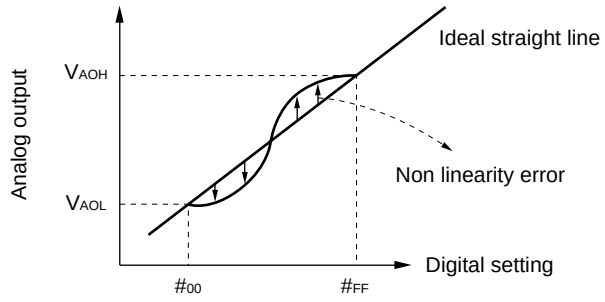
#### (2) Analog Block 1

($V_{DD}$, $V_{CC}$ = 2.7 V to 3.6 V ($V_{CC} \geq V_{DD}$) , GND = $V_S$ = 0 V, Ta = –20 °C to +85 °C)

| Parameter | Symbol | Pin | Condition | Value | | | Unit |
|---|---|---|---|---|---|---|---|
| | | | | Min | Typ | Max | |
| Power consumption | $I_{DD}$ | $V_{DD}$ | Maximum setting value from #00 to #FF | — | 0.6 | 1.5 | mA |
| Analog voltage | $V_{DD}$ | $V_{DD}$ | $V_{DD}$ – $V_{SS}$ ≥ 2.0 | 2.0 | — | $V_{CC}$ | V |
| | $V_{SS}$ | $V_{SS}$ | | GND | — | $V_{CC}$ – 2.0 | V |
| Resolution | Res | $AO_1$ to $AO_{12}$ | — | — | 8 | — | bit |
| Monotonic increase | Rem | | $V_{DD} \leq V_{CC}$ – 0.1 V, $V_{SS} \geq$ 0.1 V, no load | — | 8 | — | bit |
| Nonlinearity error | LE | | | – 1.5 | — | + 1.5 | LSB |
| Differential linearity error | $D_{LE}$ | | | – 1.0 | — | + 1.0 | LSB |

Nonlinearity error : Deviation (error) in input/output curves with respect to an ideal straight line connecting output voltage at “00” and output voltage at “FF.”

Differential linearity error : 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.

### (3) Analog Block 2

($V_{DD}$, $V_{CC}$ = 2.7 V to 3.6 V ($V_{CC} \geq V_{DD}$) , GND = $V_{SS}$ = 0 V, Ta = –20 °C to +85 °C)

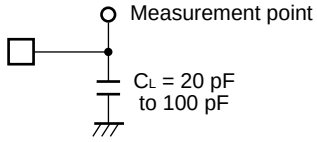
| Parameter | Symbol | Pin | Condition | Value | | | Unit |
|---|---|---|---|---|---|---|---|
| | | | | Min | Typ | Max | |
| Output minimum voltage 1 | $V_{AOL1}$ | $AO_1$ to $AO_{12}$ | $V_{DD}$ = $V_{CC}$ = 3.0 V, $V_{SS}$ = GND = 0.0 V, $I_{AL}$ = 0 μA Digital data = #00 | $V_{SS}$ | — | $V_{SS}$ + 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 | $V_{DD}$ | $V_{DD}$ + 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 | $V_{DD}$ | $V_{DD}$ + 0.3 | V |

## 2. AC Characteristics

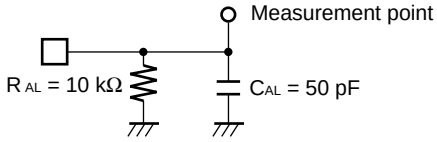
($V_{DD}$, $V_{CC}$ = 2.7 V to 3.6 V ($V_{CC} \geq V_{DD}$) , GND = $V_{SS}$ = 0 V, Ta = − 20 °C to +85 °C)

| Parameter | Symbol | Condition | Value | | Unit |
|---|---|---|---|---|---|
| | | | Min | Max | |
| Clock L level pulse width | $t_{CKL}$ | — | 200 | — | ns |
| Clock H level pulse width | $t_{CKH}$ | — | 200 | — | ns |
| Clock rise time<br>Clock fall 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 |
| Load H level pulse width | $t_{LDH}$ | — | 100 | — | ns |
| Data output delay time | $t_{DO}$ | Refer to "• Load condition 1" | 70 | 600 | ns |
| D/A output settling time | $t_{LDD}$ | Refer to "• Load condition 2" | — | 300 | µs |

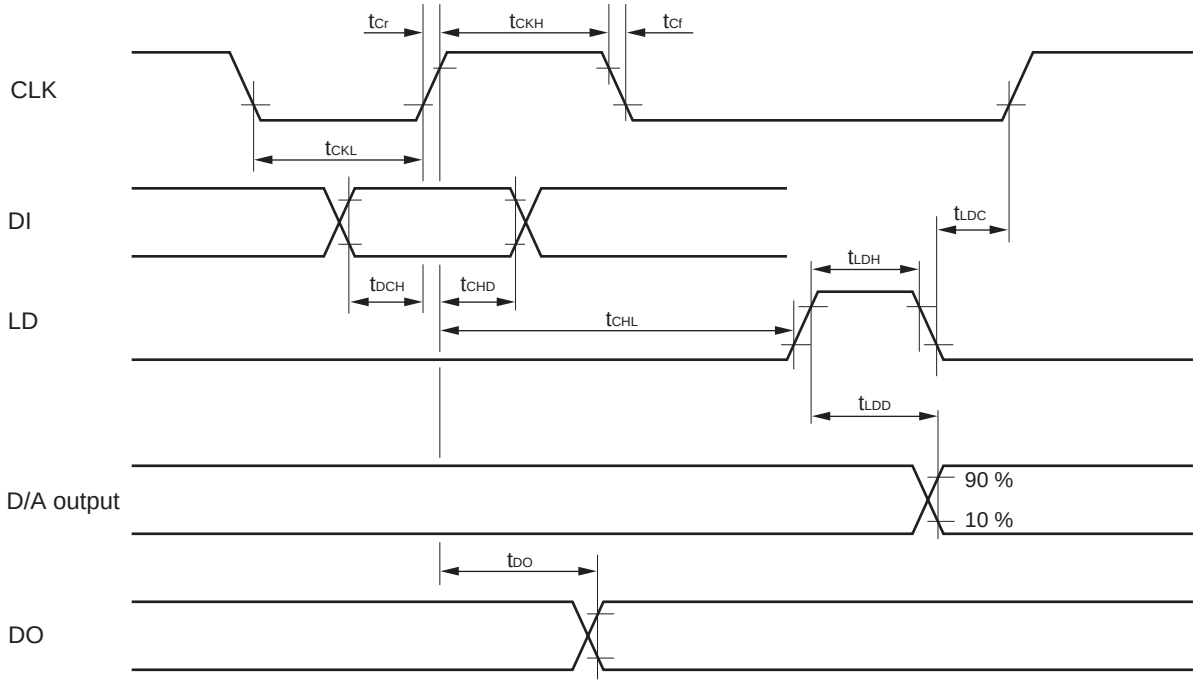
• Load condition 1




• Load condition 2

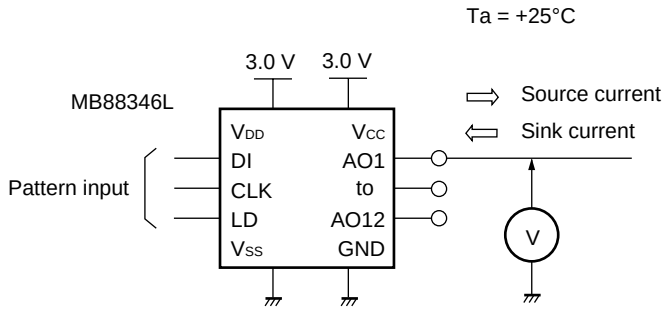


- **Input/output timing**



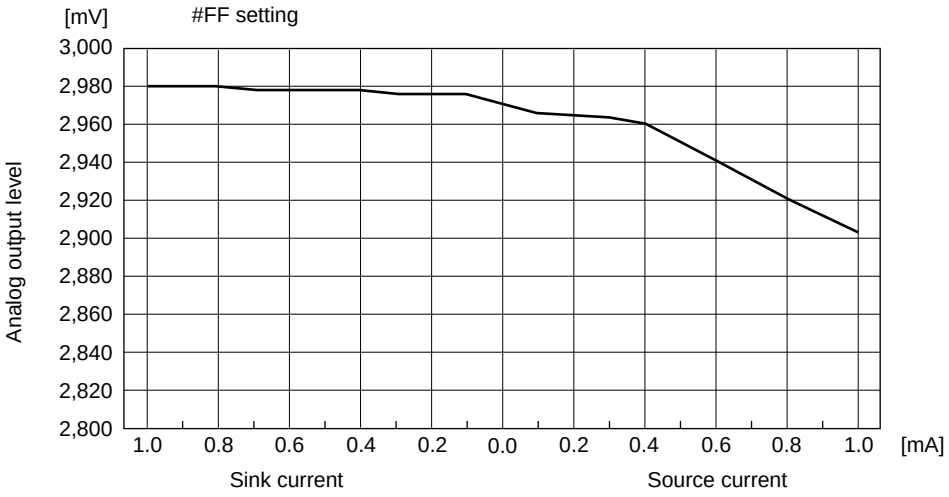

Note: Decision levels: 80 % and 20 % of $V_{CC}$

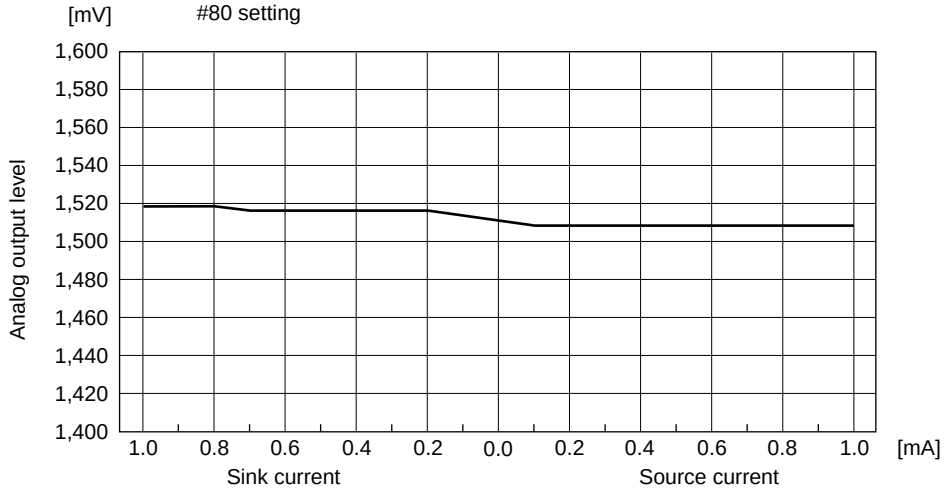
## ■ $V_{AO}$ vs. $I_{AO}$ CHARACTERISTICS : EXAMPLE

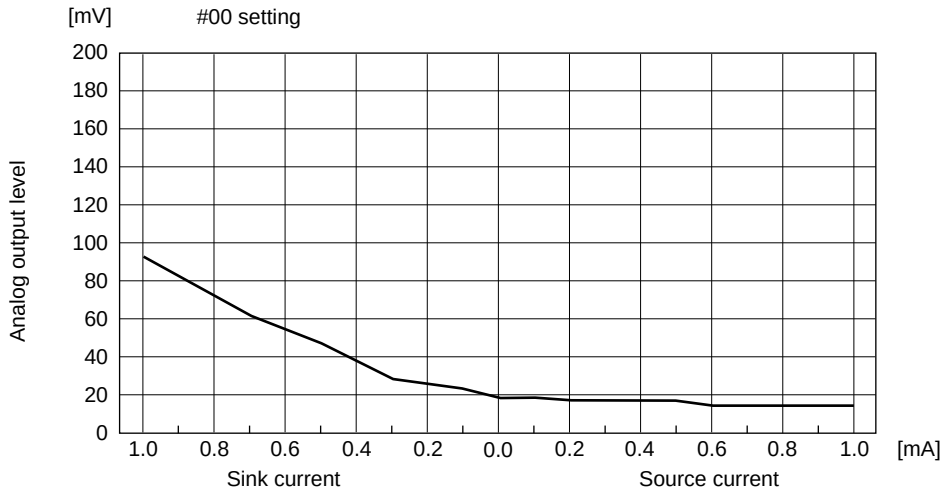



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[mV]
#FF setting
3,000
2,980
2,960
2,940
2,920
2,900
2,880
2,860
2,840
2,820
2,800
Analog output level
1.0 0.8 0.6 0.4 0.2 0.0 0.2 0.4 0.6 0.8 1.0
[mA]
Sink current
Source current

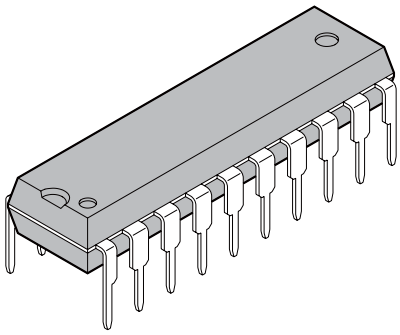

[mV]
#80 setting
1,600
1,580
1,560
1,540
1,520
1,500
1,480
1,460
1,440
1,420
1,400
Analog output level
1.0 0.8 0.6 0.4 0.2 0.0 0.2 0.4 0.6 0.8 1.0
[mA]
Sink current
Source current

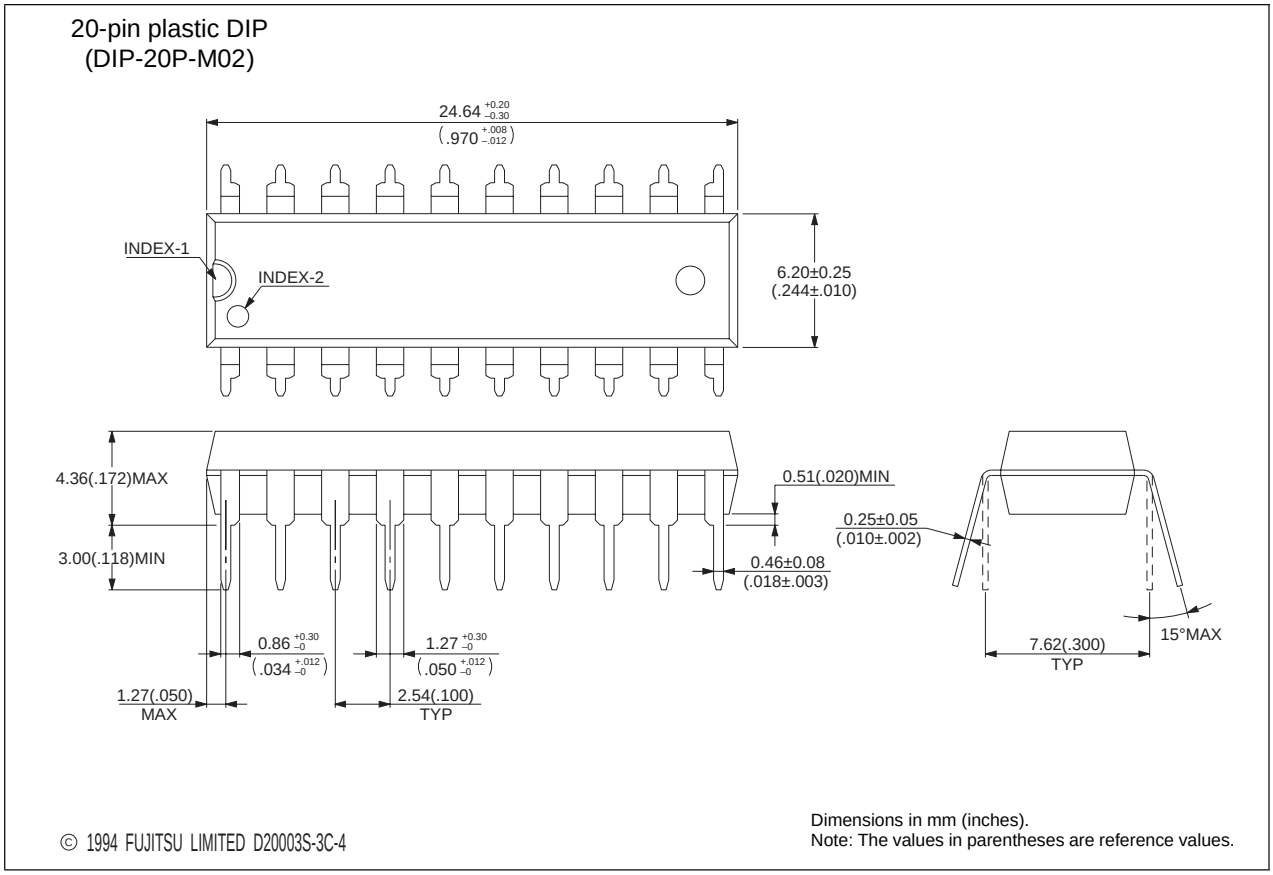

[mV]
#00 setting
200
180
160
140
120
100
80
60
40
20
0
Analog output level
1.0 0.8 0.6 0.4 0.2 0.0 0.2 0.4 0.6 0.8 1.0
[mA]
Sink current
Source current

## ■ ORDERING INFORMATION

| Part number | Package | Remarks |
|---|---|---|
| MB88346LP | 20-pin plastic DIP<br>(DIP-20P-M02) | |
| MB88346LPFV | 20-pin plastic SSOP<br>(FPT-20P-M03) | |

## ■ PACKAGE DIMENSIONS

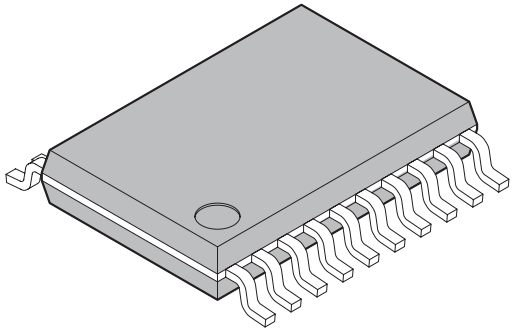
| 20-pin plastic DIP | | |
|---|---|---|
|  | Lead pitch | 2.54mm(100mil) |
| | Row spacing | 7.62mm(300mil) |
| | Sealing method | Plastic mold |
| | | |
| | | |
| | | |
| (DIP-20P-M02) | | |




Please confirm the latest Package dimension by following URL.
http://edevice.fujitsu.com/package/en-search/

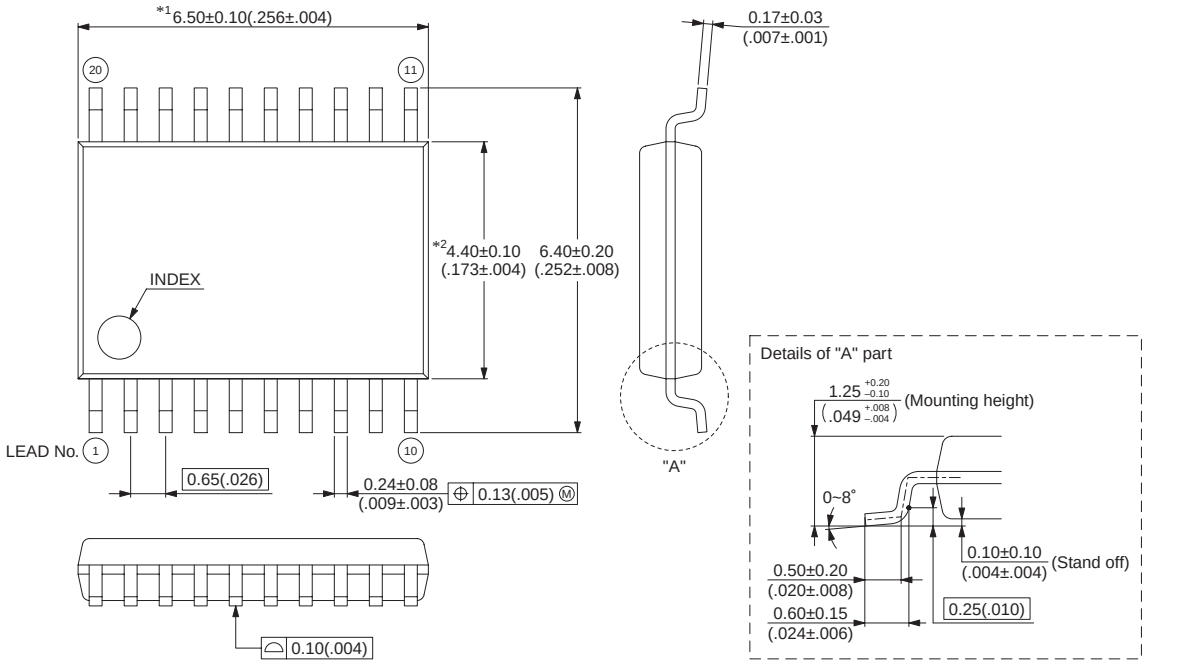
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| 20-pin plastic SSOP | | |
|---|---|---|
|  | Lead pitch | 0.65 mm |
| | Package width × package length | 4.40 × 6.50 mm |
| | Lead shape | Gullwing |
| | Sealing method | Plastic mold |
| | Mounting height | 1.45 mmMAX |
| | Weight | 0.09g |
| (FPT-20P-M03) | Code (Reference) | P-SSOP20-4.4×6.5-0.65 |

20-pin plastic SSOP
(FPT-20P-M03)

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.




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

Please confirm the latest Package dimension by following URL.
http://edevice.fujitsu.com/package/en-search/

# MEMO

MEMO

# MEMO

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