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# Linear IC General purpose Converter

## CMOS

# D/A Converter for Digital Tuning

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

# MB88346B

### ■ DESCRIPTION

The MB88346B features 12 channels of 8-bit D/A converters with output amplifier for digital tuning. The output amplifier provides high current drive capability.

As the MB88346B inputs data in serial, it requires only three control lines and can also be cascade-connected with the MB88340 series.

The MB88346B is suitable for electronic volumes and replacement for potentiometers for adjustment, in addition to normal D/A converter applications.

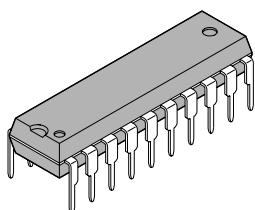
### ■ FEATURES

- Low power consumption
- Small package
- Integrating 12 channels of R-2R type 8-bit D/A converter

*(Continued)*

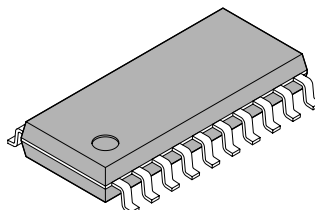
### ■ PACKAGES

20-pin plastic DIP



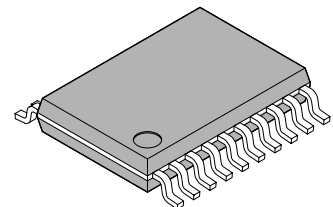
(DIP-20P-M02)

20-pin plastic SOP



(FPT-20P-M01)

20-pin plastic SSOP



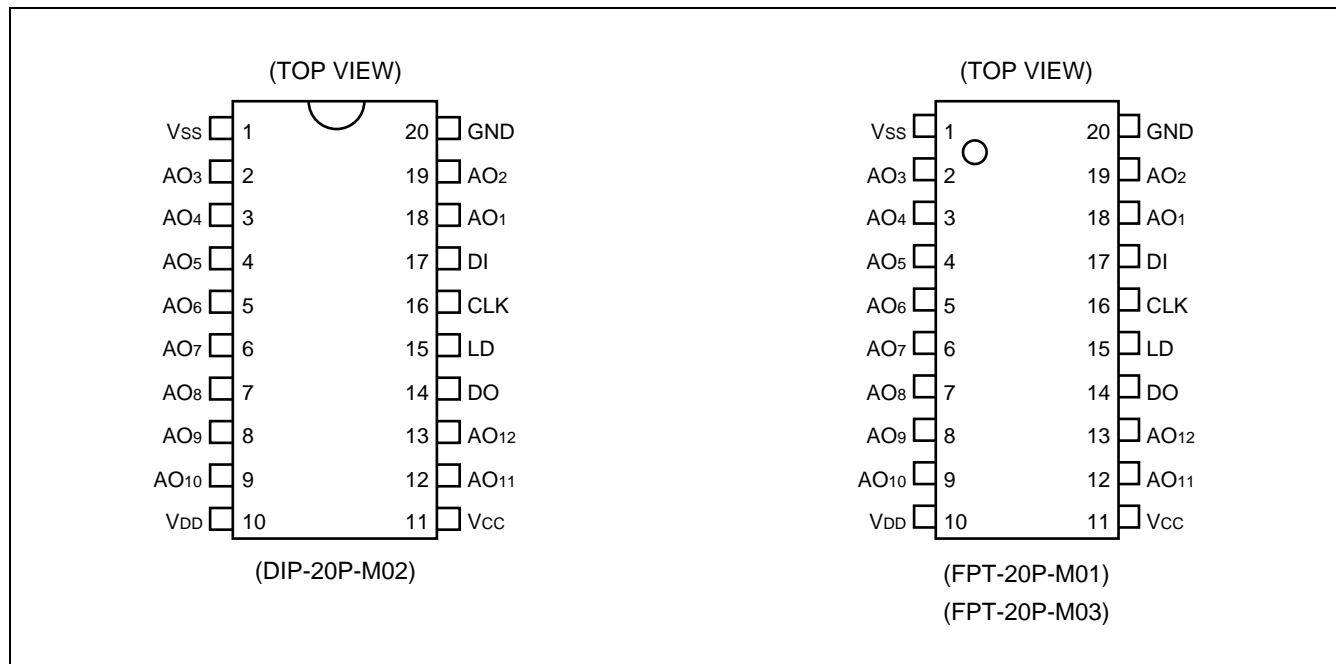
(FPT-20P-M03)

# MB88346B

*(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 20-pin, SOP 20-pin, SSOP 20-pin

## PIN ASSIGNMENTS



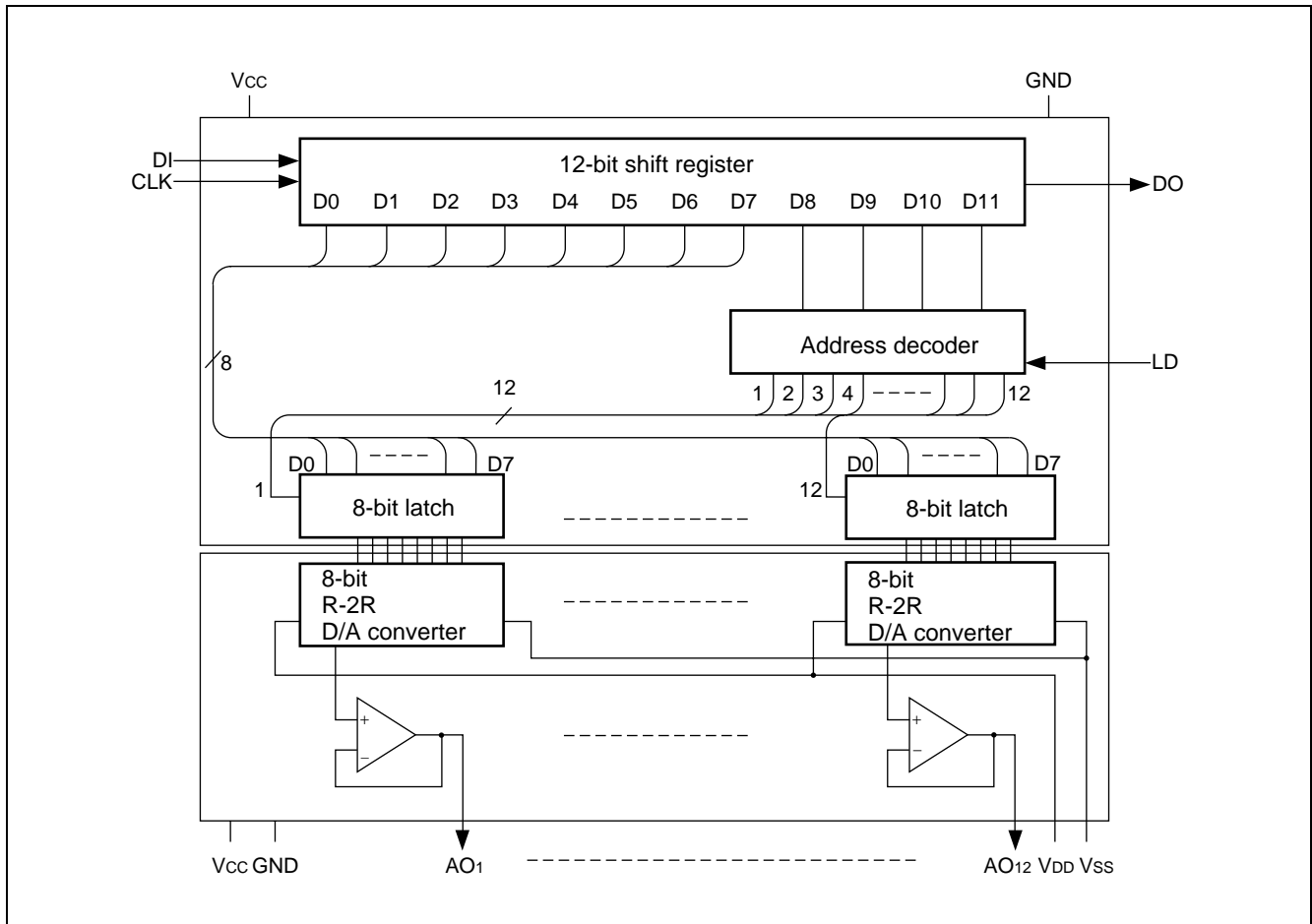
## PIN DESCRIPTION

Pin No.	Symbol	I/O	Pin name	Function
17	DI*	I	Data input pin	This pin inputs 12-bit serial data.
14	DO	O	Data output pin	This pin outputs MSB bit data of 12-bit shift register.
16	CLK*	I	Shift clock input pin	Input signal from DI pin is inputted to 12-bit shift register at rising of shift clock.
15	LD*	I	Load signal input pin	If input "H" level to LD pin, the data of 12-bit shift register is loaded to the decoder and the register for D/A output.
18, 19, 2, 3, 4, 5, 6, 7, 8, 9, 12, 13	AO <sub>1</sub> , AO <sub>2</sub> , AO <sub>3</sub> , AO <sub>4</sub> , AO <sub>5</sub> , AO <sub>6</sub> , AO <sub>7</sub> , AO <sub>8</sub> , AO <sub>9</sub> , AO <sub>10</sub> , AO <sub>11</sub> , AO <sub>12</sub>	O	D/A output pin	These pins output analog data of 8-bit D/A converter with OP amplifier.
11	V <sub>CC</sub>	—	Power supply pin	Power supply pin of MCU interface and OP amplifier
20	GND	—	Ground pin	Ground pin of MCU interface and OP amplifier
10	V <sub>DD</sub>	—	Power supply pin	Power supply pin of D/A converter
1	V <sub>SS</sub>	—	Ground pin	Ground pin of D/A converter

\* : When three pins, DI, CLK, and LD pins are connected to 3-V MCU, they are fixed to "L" level at non transfer.

# MB88346B

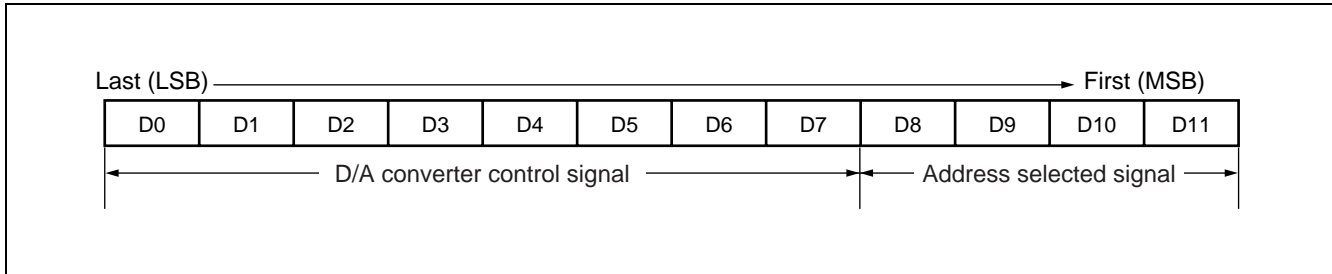
## ■ BLOCK DIAGRAM



## ■ DATA FOR CHIP CONTROL

### 1. Data for Shift Register

- The chip is controlled by 12 bits of data input to the shift register.
- The shift register inputs a total of 12 bits of data consisting of a four-bit address selection signal and an eight-bit D/A converter control signal.
- A data to the shift register is inputted to the DI pin in the order of D11 (MSB) to D0 (LSB) .



### 2. D/A Converter Control Signal

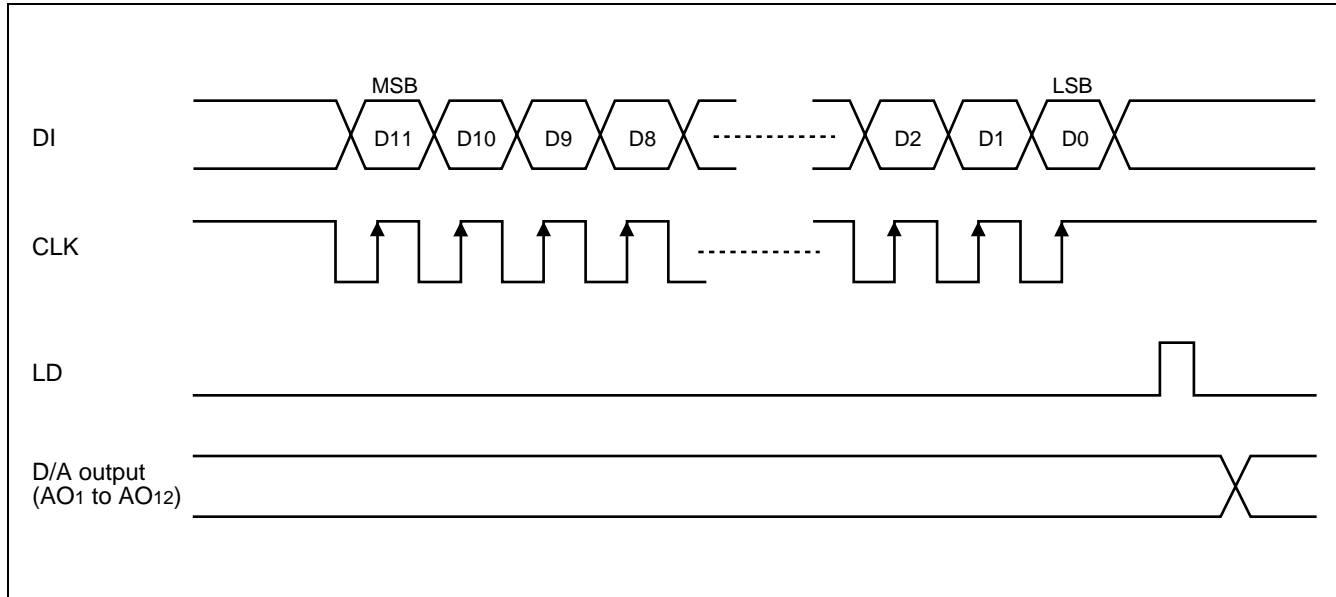
Input data signal								D/A converter output voltage
D0	D1	D2	D3	D4	D5	D6	D7	
0	0	0	0	0	0	0	0	$\cong V_{SS}$
1	0	0	0	0	0	0	0	$\cong V_{REF} / 255 \times 1 + V_{SS}$
0	1	0	0	0	0	0	0	$\cong V_{REF} / 255 \times 2 + V_{SS}$
1	1	0	0	0	0	0	0	$\cong V_{REF} / 255 \times 3 + V_{SS}$
\	\	\	\	\	\	\	\	\
0	1	1	1	1	1	1	1	$\cong V_{REF} / 255 \times 254 + V_{SS}$
1	1	1	1	1	1	1	1	$\cong V_{DD}$

$$V_{REF} = V_{DD} - V_{SS}$$

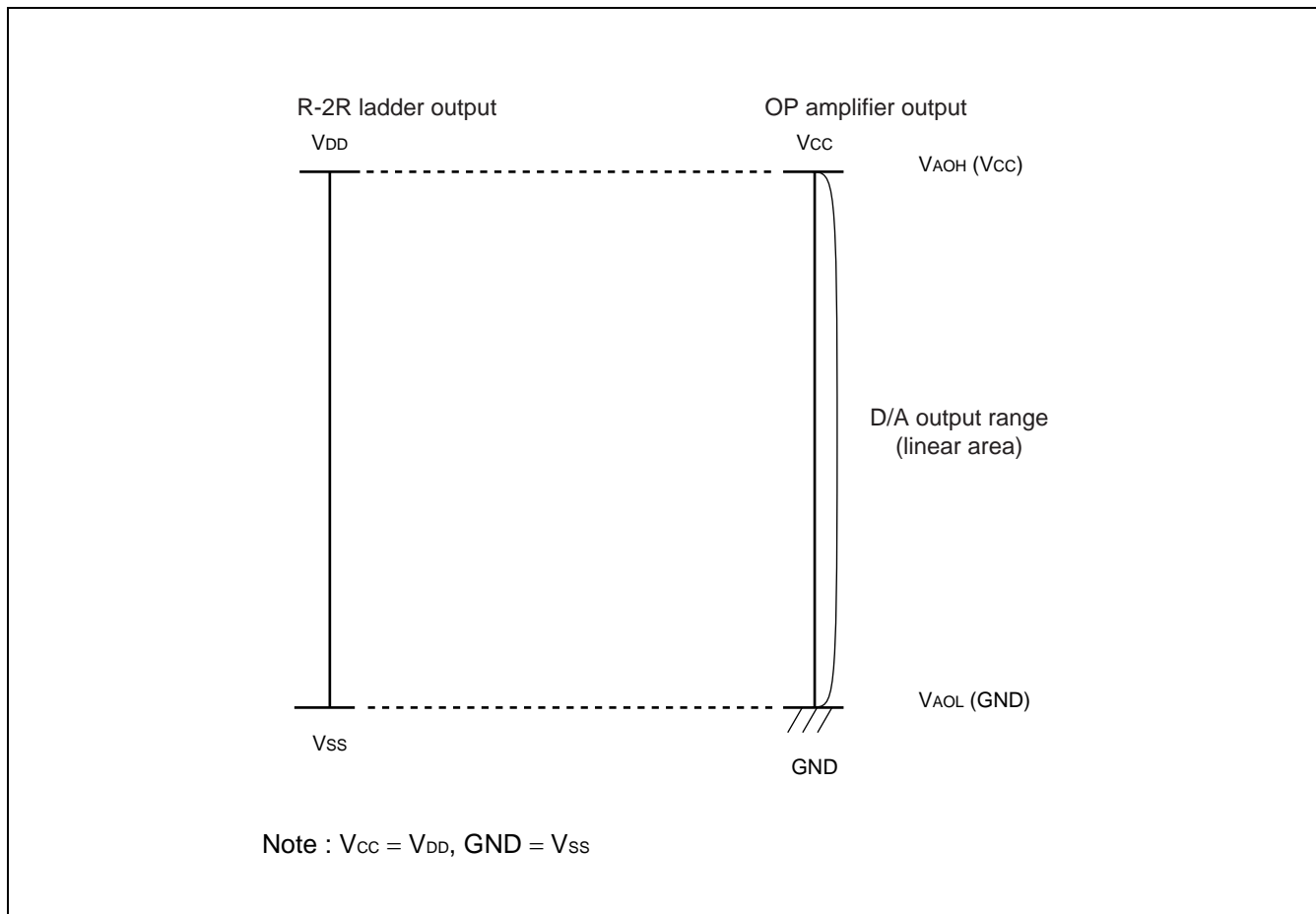
### 3. Address Selected Signal

Input data signal				Address selected sequence
D8	D9	D10	D11	
0	0	0	0	Don't Care
0	0	0	1	AO <sub>1</sub> selected
0	0	1	0	AO <sub>2</sub> selected
0	0	1	1	AO <sub>3</sub> selected
0	1	0	0	AO <sub>4</sub> selected
0	1	0	1	AO <sub>5</sub> selected
0	1	1	0	AO <sub>6</sub> selected
0	1	1	1	AO <sub>7</sub> selected
1	0	0	0	AO <sub>8</sub> selected
1	0	0	1	AO <sub>9</sub> selected
1	0	1	0	AO <sub>10</sub> selected
1	0	1	1	AO <sub>11</sub> selected
1	1	0	0	AO <sub>12</sub> selected
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





# MB88346B

## ■ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Condition	Rating		Unit	Remarks
			Min	Max		
Power supply voltage	V <sub>CC</sub>	The case that GND is referred. T <sub>a</sub> = +25 °C	- 0.3	+ 7.0	V	V <sub>CC</sub> ≥ V <sub>DD</sub>
	V <sub>DD</sub>		- 0.3	+ 7.0	V	
Input voltage	V <sub>IN</sub>		- 0.3	V <sub>CC</sub> + 0.3	V	
Output voltage	V <sub>OUT</sub>		- 0.3	V <sub>CC</sub> + 0.3	V	
Power consumption	P <sub>D</sub>	—	—	250	mW	
Operating temperature	T <sub>a</sub>	—	- 40	+ 85	°C	
Storage temperature	T <sub>stg</sub>	—	- 55	+ 150	°C	

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	Value		Unit
		Min	Max	
Power supply Voltage	V <sub>CC</sub>	4.5	5.5	V
	GND	—	0	V
Analog output source current	I <sub>source</sub>	—	1.0	mA
Analog output sink current	I <sub>sink</sub>	—	1.0	mA
Oscillation limited output capacitance	C <sub>OL</sub>	—	1.0	μF
Operating temperature	T <sub>a</sub>	- 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 representatives beforehand.

## ■ ELECTRICAL CHARACTERISTICS

### 1. DC Characteristics

#### (1) Digital block

( $V_{DD}, V_{CC} = +5\text{ V} \pm 10\% (V_{CC} \geq V_{DD})$ , GND,  $V_{SS} = 0\text{ V}$ ,  $T_a = -40\text{ }^\circ\text{C}$  to  $+85\text{ }^\circ\text{C}$ )

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)	—	2.5	4.5	mA
Input leakage current	$I_{ILK}$	CLK DI LD	$V_{IN} = 0$ to $V_{CC}$	-10	—	10	$\mu\text{A}$
“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	$I_{OL} = 2.5\text{ mA}$	—	—	0.4	V
“H” level output voltage	$V_{OH}$		$I_{OH} = -400\text{ }\mu\text{A}$	$V_{CC} - 0.4$	—	—	V

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

#### (2) Analog block

( $V_{DD}, V_{CC} = +5\text{ V} \pm 10\% (V_{CC} \geq V_{DD})$ , GND,  $V_{SS} = 0\text{ V}$ ,  $T_a = -40\text{ }^\circ\text{C}$  to  $+85\text{ }^\circ\text{C}$ )

Parameter	Symbol	Pin name	Conditions	Value			Unit
				Min	Typ	Max	
Consumption current	$I_{DD}$	$V_{DD}$	No load	—	0.2	0.5	mA
Analog power supply 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 <sub>1</sub> to AO <sub>12</sub>	Monotonic increase	—	8	—	bit
Non linearity error	LE		No load $V_{DD} \leq V_{CC} - 0.1\text{ V}$ $V_{SS} \geq 0.1\text{ V}$	-1.5	0	1.5	LSB
Differential linearity error	$D_{LE}$		No load $V_{DD} \leq V_{CC} - 0.1\text{ V}$ $V_{SS} \geq 0.1\text{ V}$	-1.0	—	1.0	LSB
Output minimum voltage 1	$V_{AOL1}$	AO <sub>1</sub> to AO <sub>12</sub>	No load, $V_{SS} = 0\text{ V}$ When digital setting is #00.	$V_{SS}$	—	$V_{SS} + 0.1$	V
Output minimum voltage 2	$V_{AOL2}$		$I_{source} = 500\text{ }\mu\text{A}$ When digital setting is #00.	$V_{SS} - 2.0$	$V_{SS}$	$V_{SS} + 0.2$	V
Output minimum voltage 3	$V_{AOL3}$		$I_{sink} = 500\text{ }\mu\text{A}$ When digital setting is #00.	$V_{SS}$	—	$V_{SS} + 0.2$	V
Output minimum voltage 4	$V_{AOL4}$		$V_{DD} = V_{CC} = 5.0\text{ V}$ $V_{SS} = \text{GND} = 0.0\text{ V}$ $I_{source} = 1.0\text{ mA}$ When digital setting is #00.	$V_{SS} - 0.3$	$V_{SS}$	$V_{SS} + 0.3$	V
Output minimum voltage 5	$V_{AOL5}$		$V_{DD} = V_{CC} = 5.0\text{ V}$ $V_{SS} = \text{GND} = 0.0\text{ V}$ $I_{sink} = 1.0\text{ mA}$ When digital setting is #00.	$V_{SS}$	—	$V_{SS} + 0.3$	V

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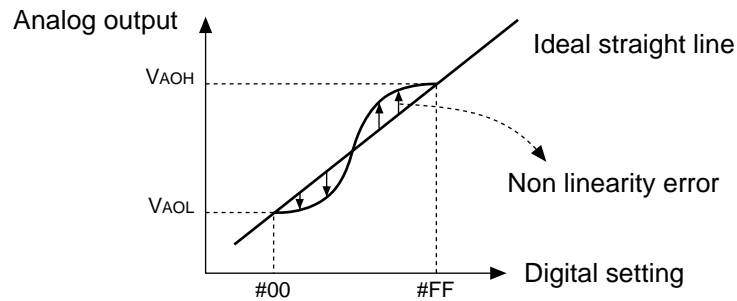
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( $V_{DD}, V_{CC} = +5\text{ V} \pm 10\% (V_{CC} \geq V_{DD})$ ,  $GND, V_{SS} = 0\text{ V}$ ,  $T_a = -40\text{ }^\circ\text{C}$  to  $+85\text{ }^\circ\text{C}$ )

Parameter	Symbol	Pin name	Conditions	Value			Unit
				Min	Typ	Max	
Output maximum voltage 1	$V_{AOH1}$	AO <sub>1</sub> to AO <sub>12</sub>	No load, $V_{DD} = V_{CC}$ When digital setting is #FF.	$V_{DD} - 0.1$	—	$V_{DD}$	V
Output maximum voltage 2	$V_{AOH2}$		$I_{source} = 500\text{ }\mu\text{A}$ When digital setting is #FF.	$V_{DD} - 0.2$	—	$V_{DD}$	V
Output maximum voltage 3	$V_{AOH3}$		$I_{sink} = 500\text{ }\mu\text{A}$ When digital setting is #FF.	$V_{DD} - 0.2$	$V_{DD}$	$V_{DD} + 0.2$	V
Output maximum voltage 4	$V_{AOH4}$		$V_{DD} = V_{CC} = 5.0\text{ V}$ $V_{SS} = GND = 0.0\text{ V}$ $I_{source} = 1.0\text{ mA}$ When digital setting is #FF.	$V_{DD} - 0.3$	—	$V_{DD}$	V
Output maximum voltage 5	$V_{AOH5}$		$V_{DD} = V_{CC} = 5.0\text{ V}$ $V_{SS} = GND = 0.0\text{ V}$ $I_{sink} = 1.0\text{ mA}$ When digital setting is #FF.	$V_{DD} - 0.3$	$V_{DD}$	$V_{DD} + 0.3$	V

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

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



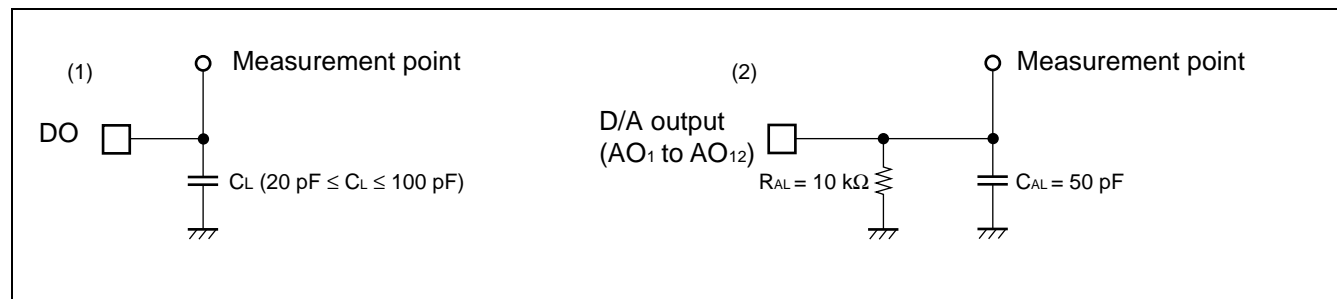
Note :  $V_{AOH}$  and  $V_{AOL}$  do not always match  $V_{DD}$  and  $V_{SS}$ , respectively.

## 2. AC Characteristics

( $V_{DD}, V_{CC} = +5\text{ V} \pm 10\%$  ( $V_{CC} \geq V_{DD}$ ),  $GND, V_{SS} = 0\text{ V}$ ,  $T_a = -40\text{ }^\circ\text{C}$  to  $+85\text{ }^\circ\text{C}$ )

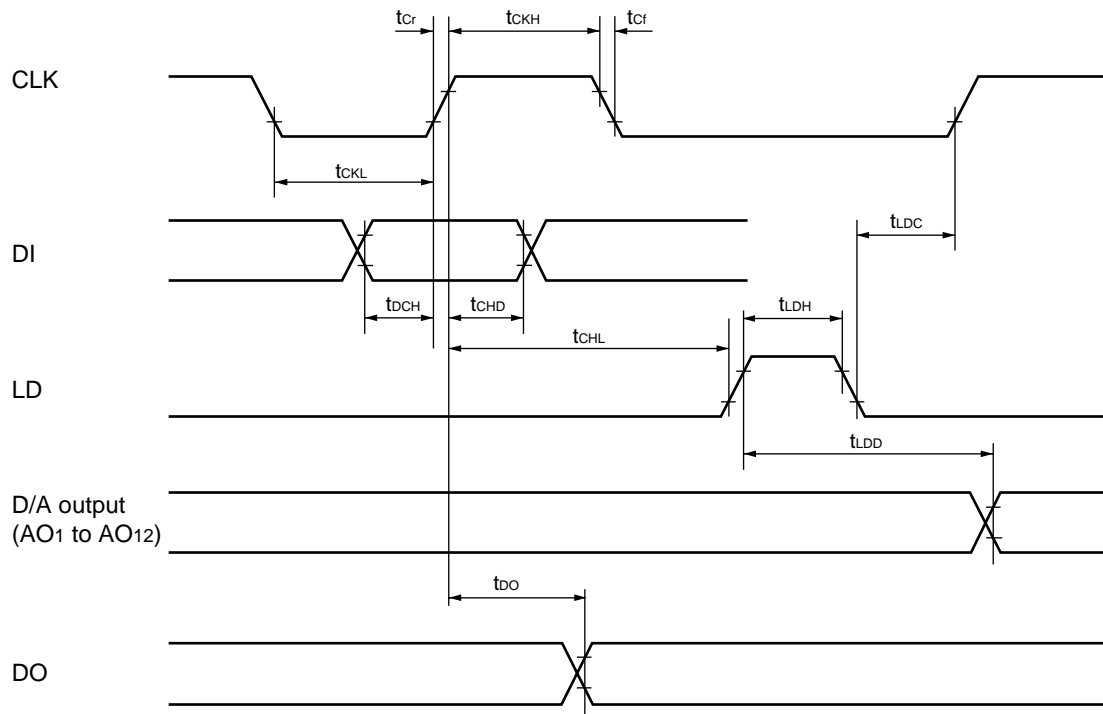
Parameter	Symbol	Conditions	Value		Unit
			Min	Max	
"L" level clock pulse width	$t_{CKL}$	—	200	—	ns
"H" level clock pulse width	$t_{CKH}$	—	200	—	
Clock rising time Clock falling time	$t_{Cr}$ $t_{Cf}$	—	—	200	
Data setup time	$t_{DCH}$	—	30	—	
Data hold time	$t_{CHD}$	—	60	—	
Load setup time	$t_{CHL}$	—	200	—	
Load hold time	$t_{LDC}$	—	100	—	
"H" level load pulse width	$t_{LDH}$	—	100	—	
Data output delay time	$t_{DO}$	Refer to "Load condition (1)".	70	350	
D/A output settling time	$t_{LDD}$	Refer to "Load condition (2)".	—	20	$\mu\text{s}$

### • Load condition



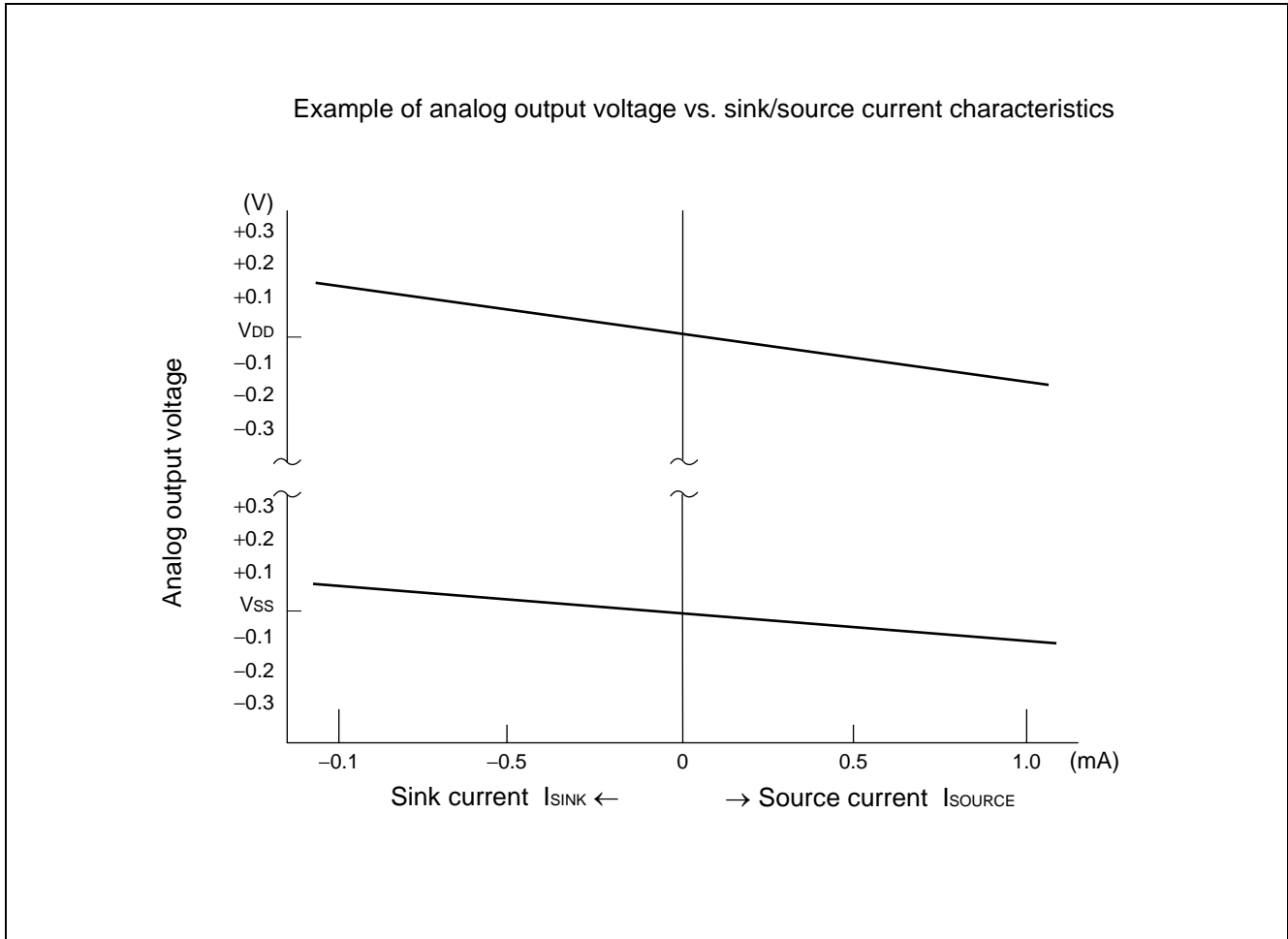
# MB88346B

## • 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 CHARACTERISTICS



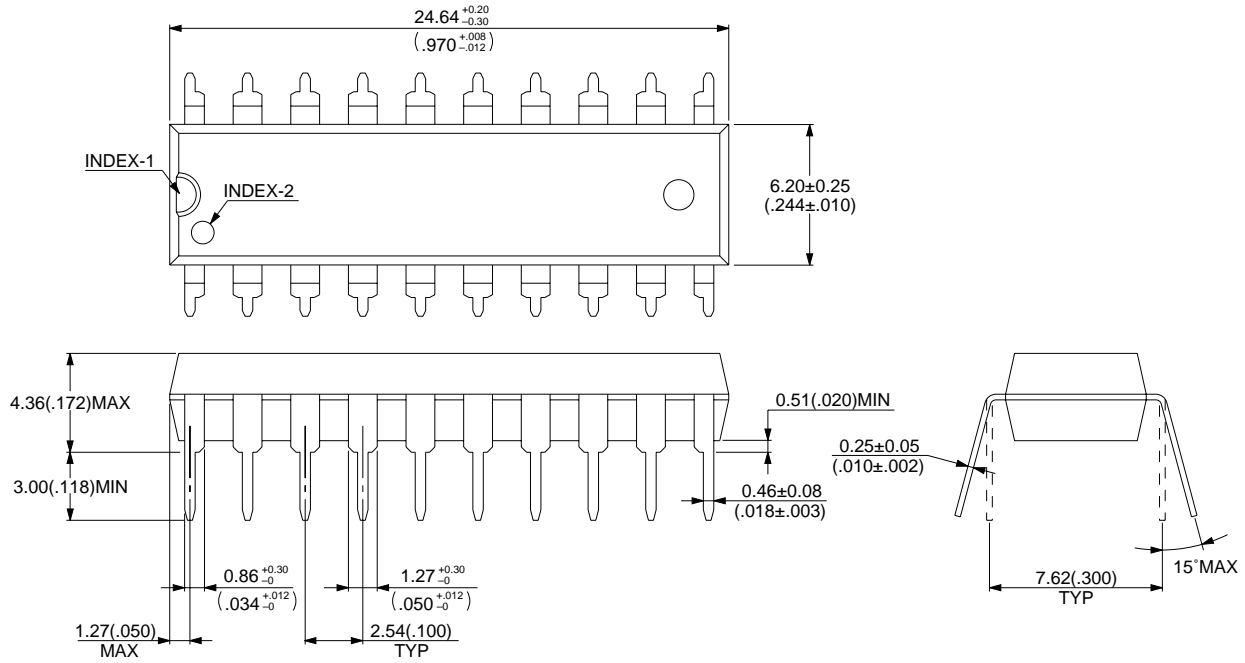
# MB88346B

## ■ ORDERING INFORMATION

Part No.	Package	Remarks
MB88346BP	20-pin plastic DIP (DIP-20P-M02)	
MB88346BPF	20-pin plastic SOP (FPT-20P-M01)	
MB88346BPFV	20-pin plastic SSOP (FPT-20P-M03)	

## ■ PACKAGE DIMENSIONS

20-pin plastic DIP  
(DIP-20P-M02)



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Dimensions in mm (inches).

Note : The values in parentheses are reference values.

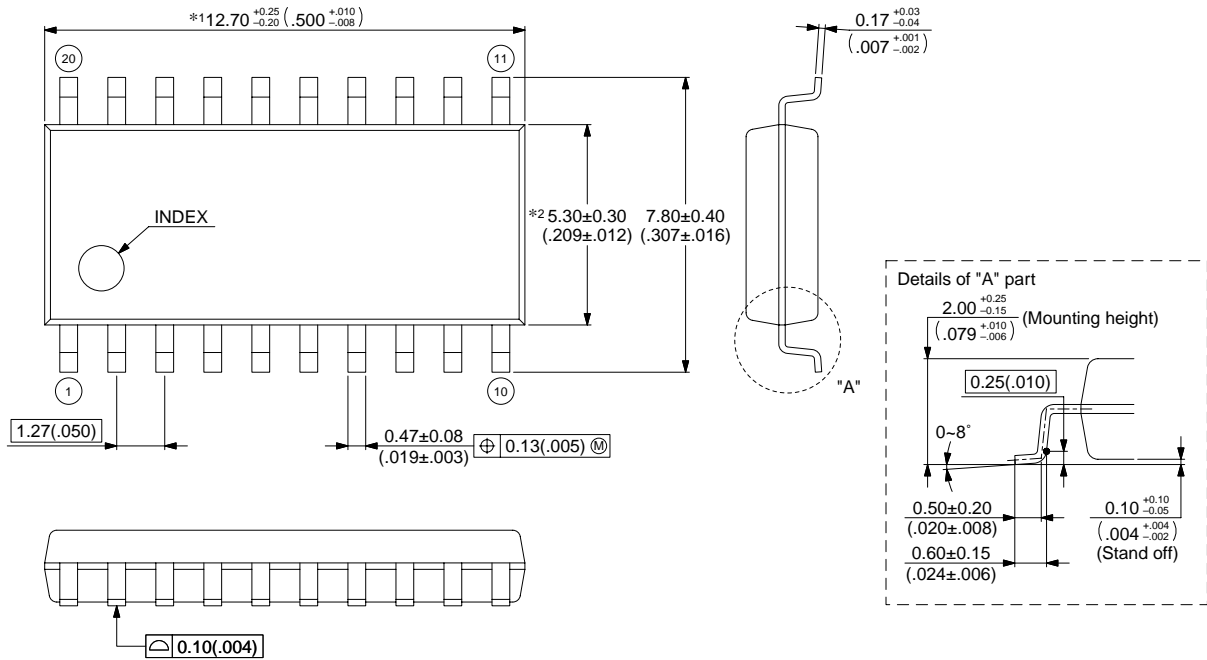
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# MB88346B

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

- 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.



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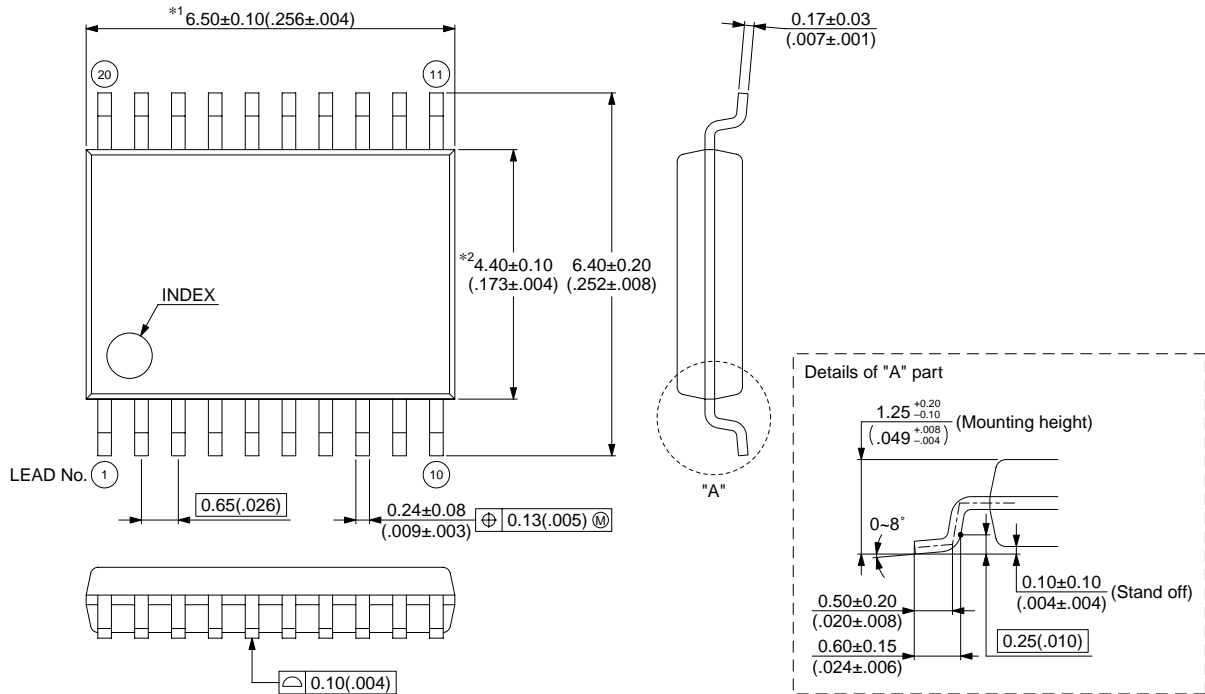
Dimensions in mm (inches).  
Note: The values in parentheses are reference values.

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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.

**MEMO**



**MEMO**



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