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# Linear IC Converter

CMOS

# A/D Converter

## (With 4-channel Input at 12-bit Resolution)

# MB88101A

### ■ DESCRIPTION

The MB88101A is an analog-to-digital converter that converts its analog input to a 12-bit digital value and outputs it as serial data.

The MB88101A employs a successive approximation method for A/D conversion.

The MB88101A has four input channels selectable for analog input under control of the dedicated external pins.

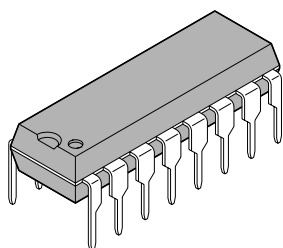
The MB88101A can be switched to a mode for continuous A/D conversion, in which it outputs serial data from the MSB or LSB selectable depending on the mode setting.

### ■ FEATURES

- 4-channel analog input
- One analog input channel selectable for conversion by external control
- CR-type successive approximation system with a sample-and-hole circuit
- 12-bit resolution
- Serial output of 12-bit digital data
- Capable of continuous conversion (continuous conversion mode)
- MSB or LSB selectable for serial output
- CMOS process
- Package options of 16-pin DIP, 16-pin SSOP, and 16-pin SOP available

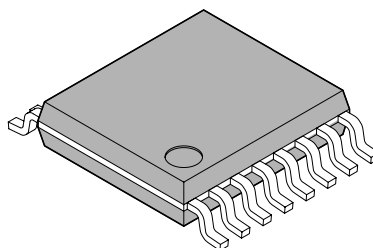
### ■ PACKAGES

16-pin Plastic DIP



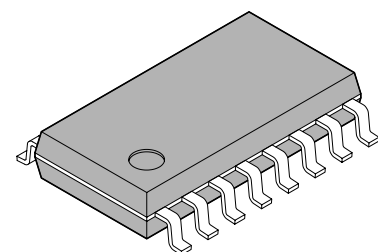
(DIP-16P-M04)

16-pin Plastic SSOP



(FPT-16P-M05)

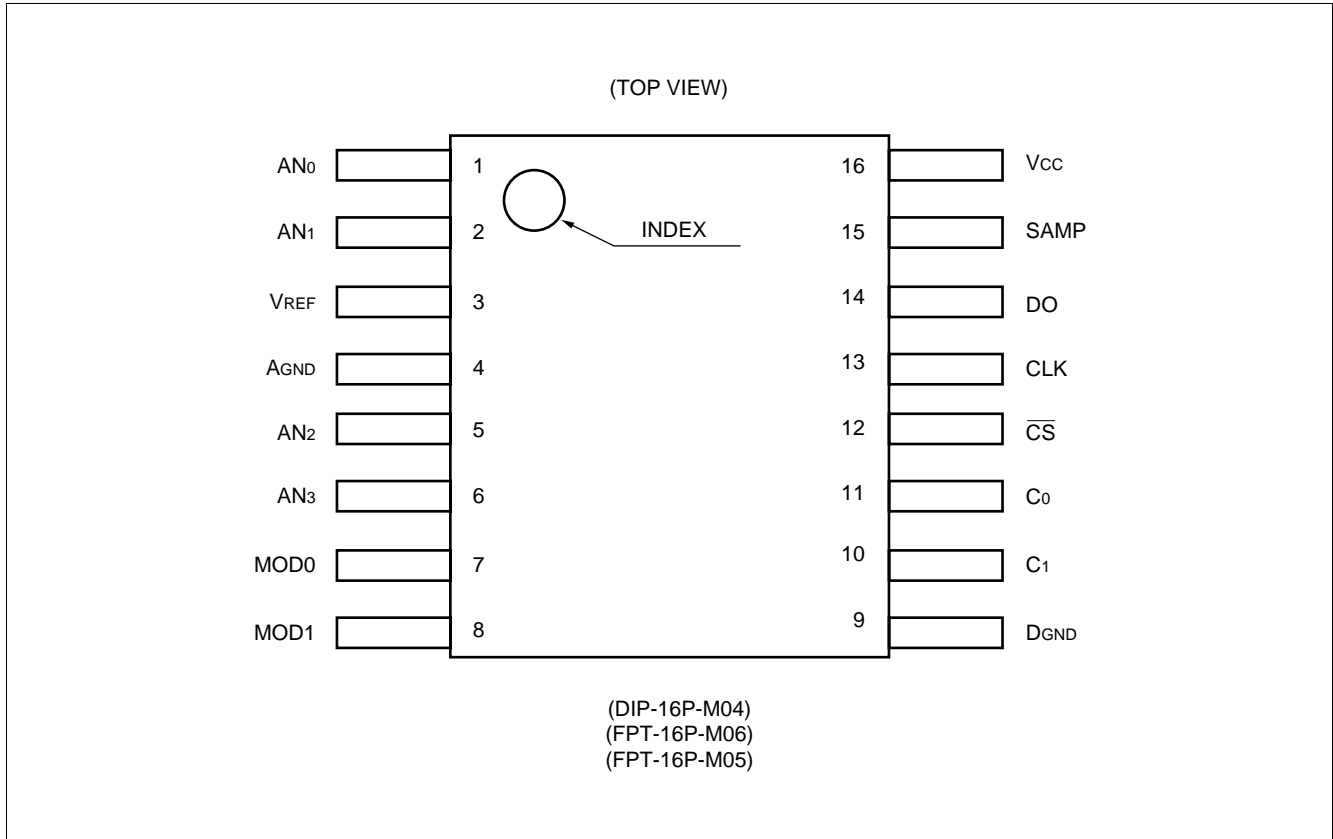
16-pin Plastic SOP



(FPT-16P-M06)

# MB88101A

## ■ PIN ASSIGNMENT



## ■ PIN DESCRIPTION

Pin no.	Symbol	I/O	Descriptions
1 2 5 6	AN <sub>0</sub> AN <sub>1</sub> AN <sub>2</sub> AN <sub>3</sub>	I	Analog input pins. One of these channels can be selected depending on the C <sub>0</sub> and C <sub>1</sub> settings.
14	DO	O	This pin outputs the result of A/D conversion. The result is 12-bit serial data output in synchronization with the rise of CLK.
13	CLK	I	Clock input pin for A/D conversion
12	$\overline{CS}$	I	Chip select signal input pin. Setting the signal level to "L" after turning the power on starts A/D conversion; setting it to "H" stops A/D conversion. When this pin is "H", the DO and SAMP pins are "Hi-Z".
11 10	C <sub>0</sub> C <sub>1</sub>	I	Input pins for selecting the analog input channels from among pins AN <sub>0</sub> to AN <sub>3</sub> . See Table 1 for the correspondence between the pin settings and the channels selected. To switch the channel in mode 2 or 3, set these pins before the SAMP pin goes "H".
7 8	MOD0 MOD1	I	Conversion mode setting pins. For the correspondence between the pin settings and the modes selected, see Table 2 and "■ FUNCTIONAL DESCRIPTION."
15	SAMP	O	This pin becomes active in prior to data output. Serial data is output from the DO pin five clock cycles after the signal level at this pin goes "L" after "H" for one clock cycle.
3	V <sub>REF</sub>	—	Reference voltage input pin
4	A <sub>GND</sub>	—	Analog circuit ground pin
9	D <sub>GND</sub>	—	Digital circuit ground pin
16	V <sub>CC</sub>	—	Power supply pin

Hi-Z : High-Z

### • Channel selection

**Table 1 Pin Settings and Channel Selection**

C <sub>1</sub>	C <sub>0</sub>	Channel
L	L	AN <sub>0</sub>
L	H	AN <sub>1</sub>
H	L	AN <sub>2</sub>
H	H	AN <sub>3</sub>

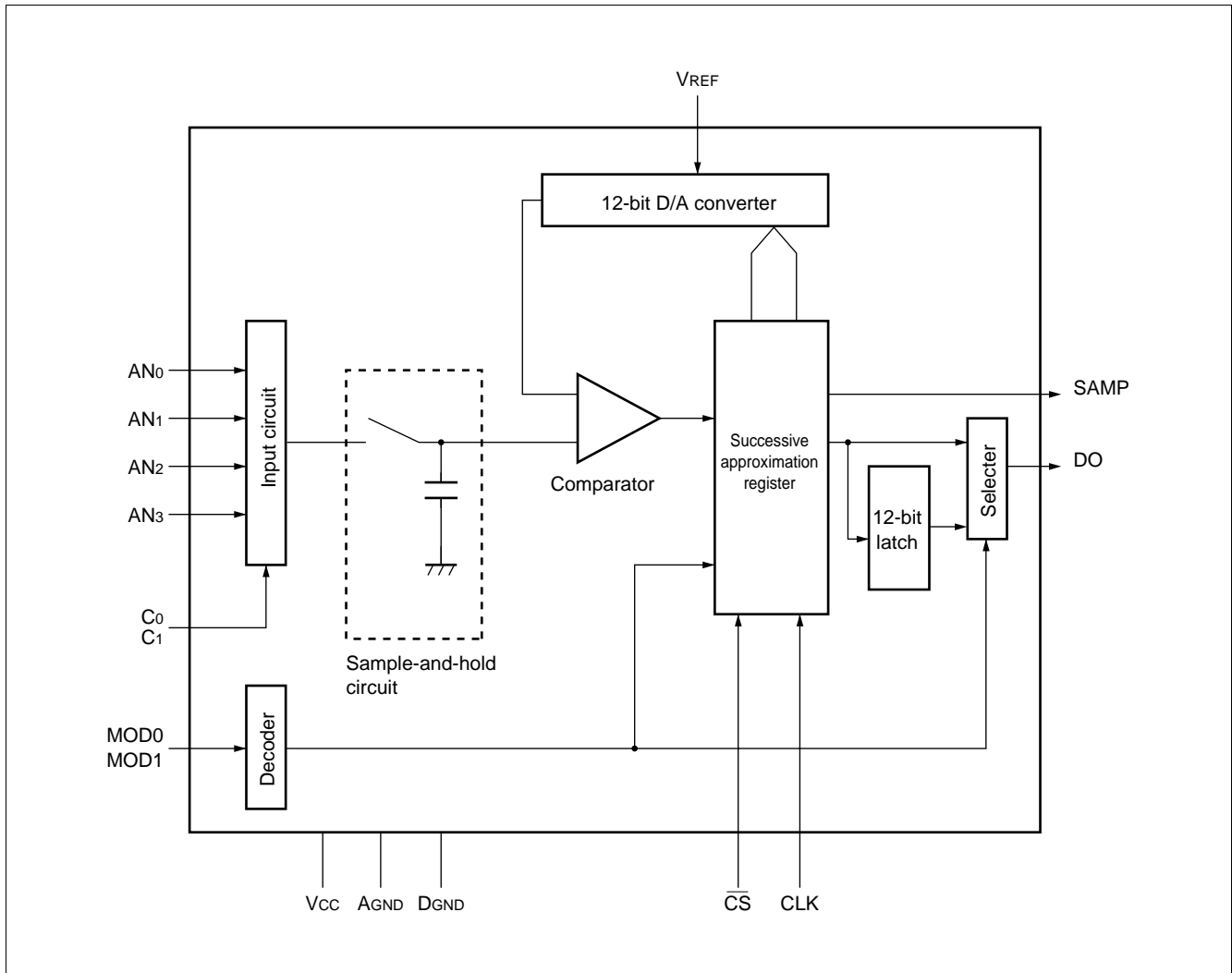
### • Mode selection

**Table 2 Pin Settings and Mode Selection**

MOD 0	MOD1	Mode
L	L	Mode 1
L	H	Mode 2
H	L	(Disabled)
H	H	Mode 3

# MB88101A

## ■ BLOCK DIAGRAM

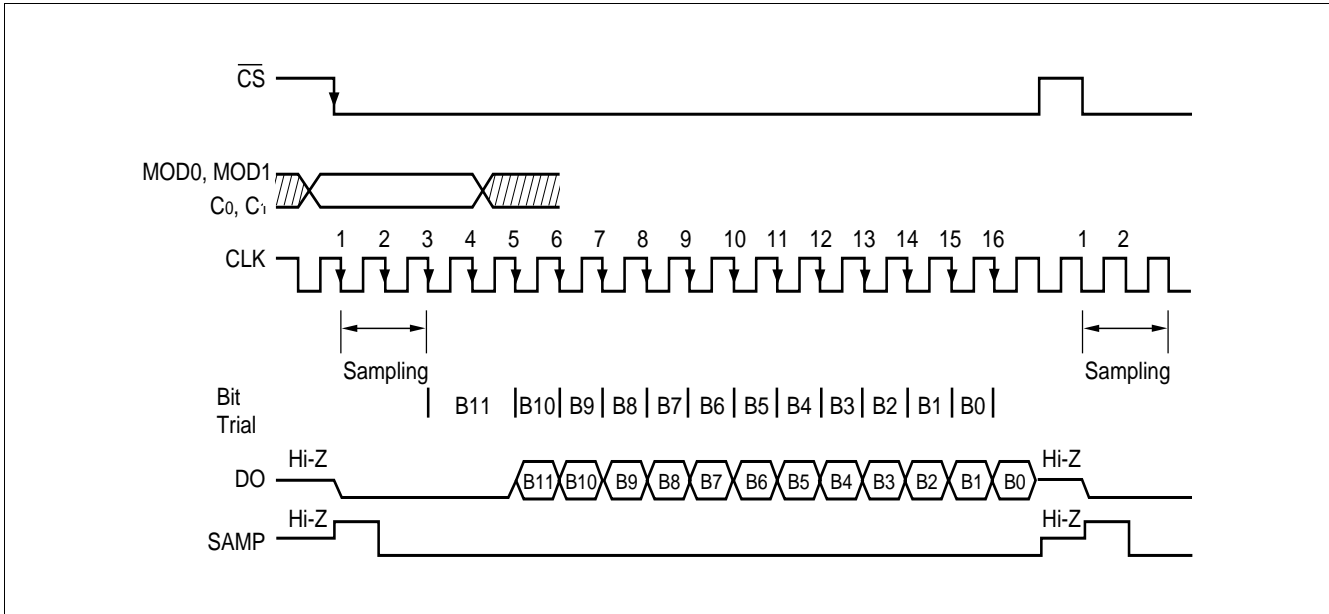


## FUNCTIONAL DESCRIPTION

### 1. Mode 1

This mode sets the DO pin to “L” and stops conversion upon completion of conversion of 12 bits. To restart conversion, set  $\overline{CS}$  to “H” once then to “L”. In this mode, converted data is output from the MSB.

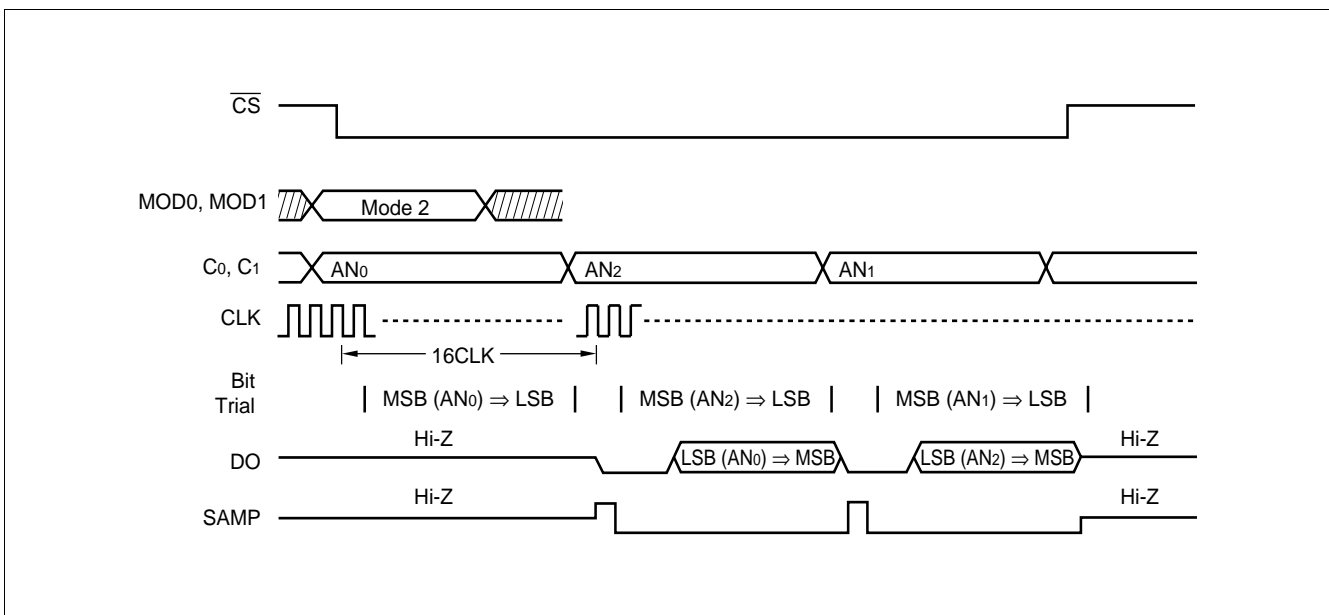
• **Timing diagram**



### 2. Mode 2

This mode continues conversion until  $\overline{CS}$  becomes “H” after it becomes “L”. Converted data is output from the LSB, with the first piece of converted data output 20 clock cycles after  $\overline{CS}$  becomes “L”. Changing the channel select pin settings before starting sampling of one analog input allows another to be converted.

• **Timing diagram**

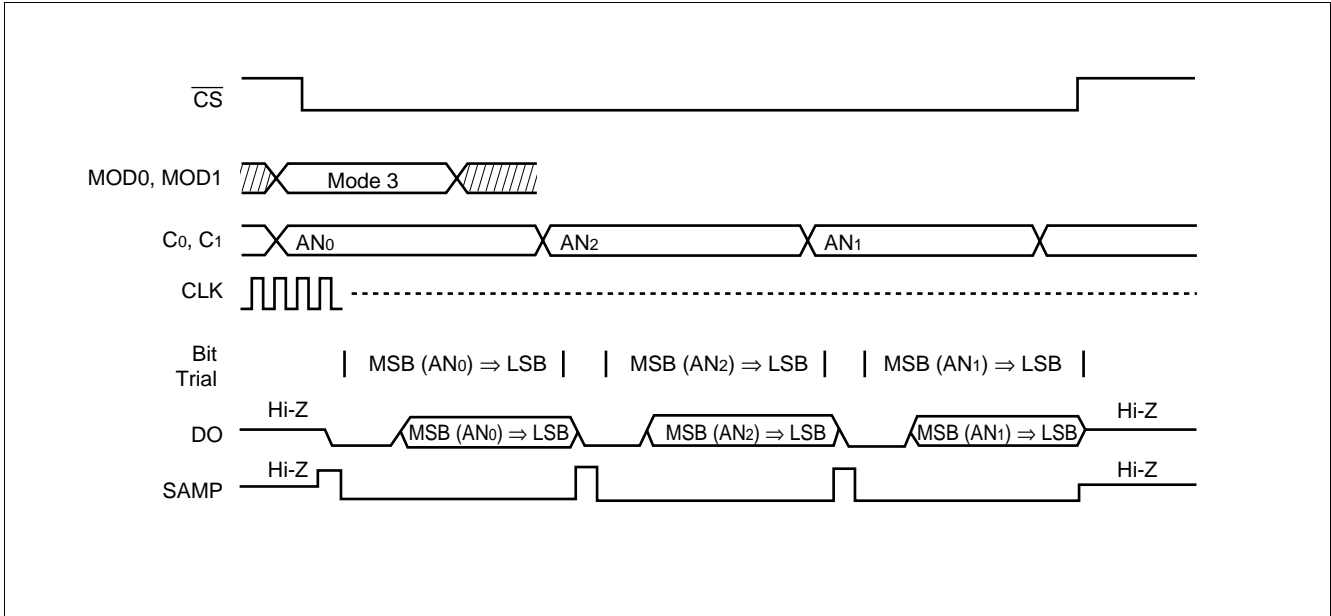


# MB88101A

## 3. Mode 3

This mode continues conversion until  $\overline{CS}$  becomes "H" after it becomes "L". Converted data is output from the MSB. Changing the channel select pin settings before starting sampling of one analog input allows another to be converted.

- Timing diagram



## ■ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Conditions	Rating		Unit
			Min	Max	
Power supply voltage	V <sub>CC</sub>	Based on GND (T <sub>a</sub> = +25°C)	-0.3	+7.0	V
	V <sub>REF</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>	—	—	150	mW
Operating temperature	T <sub>a</sub>	—	-40	+85	°C
Storage temperature	T <sub>stg</sub>	—	-55	+150	°C

\* : V<sub>CC</sub> ≥ V<sub>REF</sub>

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	Typ	Max	
Power supply voltage	V <sub>CC</sub>	3.3	—	5.5	V
	GND	—	0	—	V
Operation 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.



# MB88101A

## ■ ELECTRICAL CHARACTERISTIC

### 1. DC Characteristics

#### (1) Digital section

( $V_{CC} = 3.3\text{ V to }5.5\text{ V}$ ,  $D_{GND} = 0\text{ V}$ ,  $T_a = -40^\circ\text{C to }+85^\circ\text{C}$ )

Parameter	Symbol	Pin name	Conditions	Value			Unit
				Min	Typ	Max	
Power supply voltage	$V_{CC}$	$V_{CC}$	—	3.3	5.0	5.5	V
Power supply current	$I_{CC}$		Operation at CLK = 166kHz (with no load)	—	0.8	2.0	mA
Input leakage current	$I_{ILK}$	MOD0, MOD1 CLK CS C <sub>0</sub> C <sub>1</sub>	$V_{IN} = 0\text{ to }V_{CC}$	-10	—	10	$\mu\text{A}$
Low-level input voltage	$V_{IL}$		—	$V_{SS} - 0.3$	—	$0.2 V_{CC}$	V
High-level input voltage	$V_{IH}$		—	$0.8 V_{CC}$	—	$V_{CC} + 0.3$	V
High-impedance output leakage current	$I_{OLZ}$	DO SAMP	$V_{IN} = 0\text{ to }V_{CC}$	-10	—	10	$\mu\text{A}$
Low-level output voltage	$V_{OL}$		$I_{OL} = 2.5\text{ mA}$	—	—	0.4	V
High-level output voltage	$V_{OH}$		$I_{OH} = -400\ \mu\text{A}$	$V_{CC} - 0.4$	—	—	V

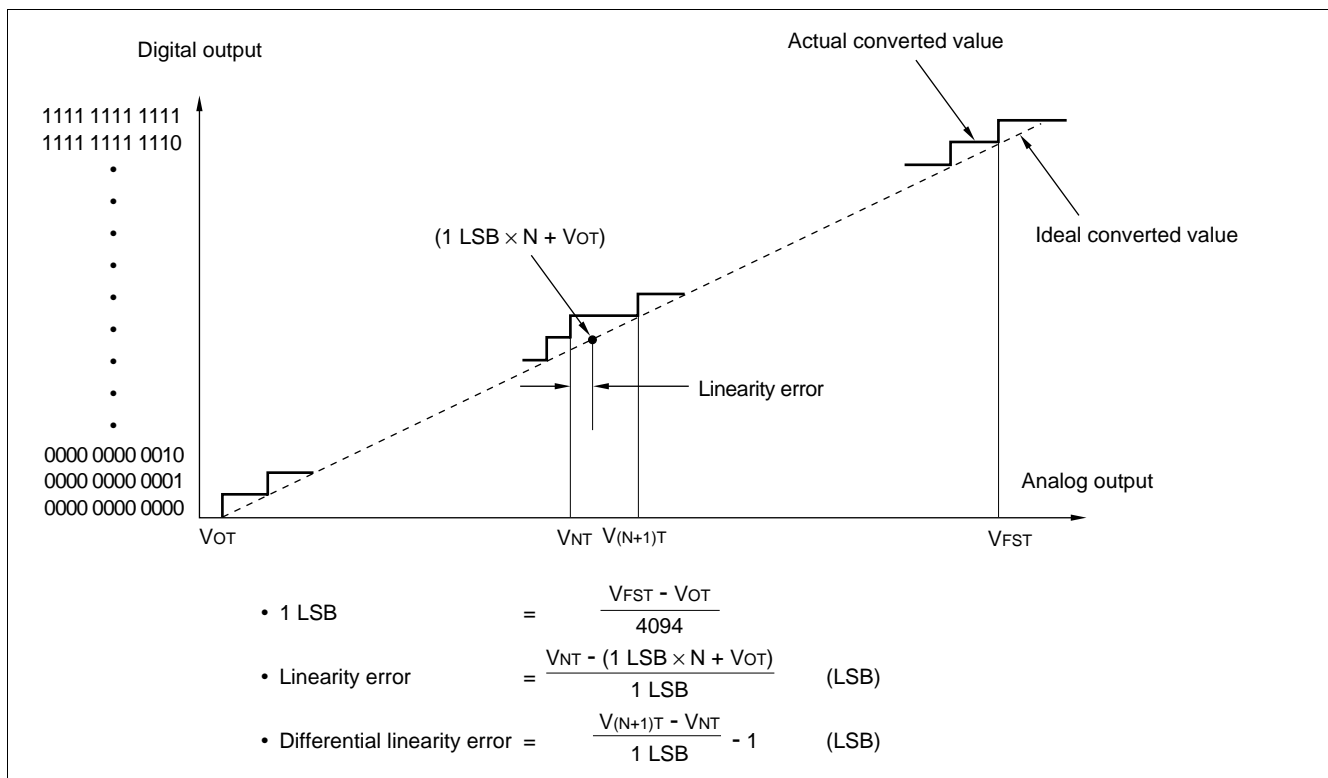
#### (2) Analog section

( $V_{REF}, V_{CC} = 3.3\text{ V to }5.5\text{ V}$  ( $V_{CC} \geq V_{REF}$ ),  $A_{GND} = 0\text{ V}$ ,  $T_a = -40^\circ\text{C to }+85^\circ\text{C}$ )

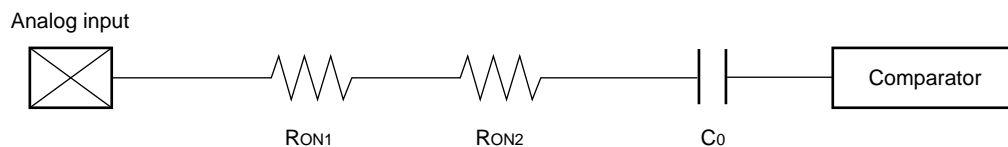
Parameter	Symbol	Pin name	Value			Unit
			Min	Typ	Max	
Resolution	—	AN <sub>0</sub> to AN <sub>3</sub>	—	12	—	bit
Linearity error	—		-4.0	—	2.0	LSB
Differential linearity error	—		-1.0	—	3.0	LSB
Conversion time	—	—	—	16	—	CLK
Consumption current	$I_{REF}$	$V_{REF}$	—	100	300	$\mu\text{A}$
Analog reference voltage	—		3.3	5.0	$V_{CC}$	V
Analog input voltage	—	AN <sub>0</sub> to AN <sub>3</sub>	0	—	$V_{REF}$	V

### (3) Definitions of A/D converter terms

- Resolution  
Analog transition identifiable by the A/D converter
- Linearity error  
Deviation of the straight line drawn between the zero transition point (0000 0000 0000 ↔ 0000 0000 0001) and the full-scale transition point (1111 1111 1110 ↔ 1111 1111 1111) of the device from actual conversion characteristics
- Differential linearity error  
Deviation from the ideal input voltage required to shift output code by one LSB



### • Analog input equivalent circuit



- RON1 = About 1.5 kΩ
- RON2 = About 1.5 kΩ
- C0 = About 60 pF

**Note:** The above values are reference values.

- Notes:
- The tolerance of output impedance of an external circuit connected to this A/D converter has an effect on conversion time (CLK frequency). See "■ TYPICAL CHARACTERISTICS".
  - If the output impedance of the external input is too high, the analog voltage sampling time may be short.
  - When turning the device on, turn the power supply for the digital system first before turning VREF on.

# MB88101A

## 2. AC Characteristics

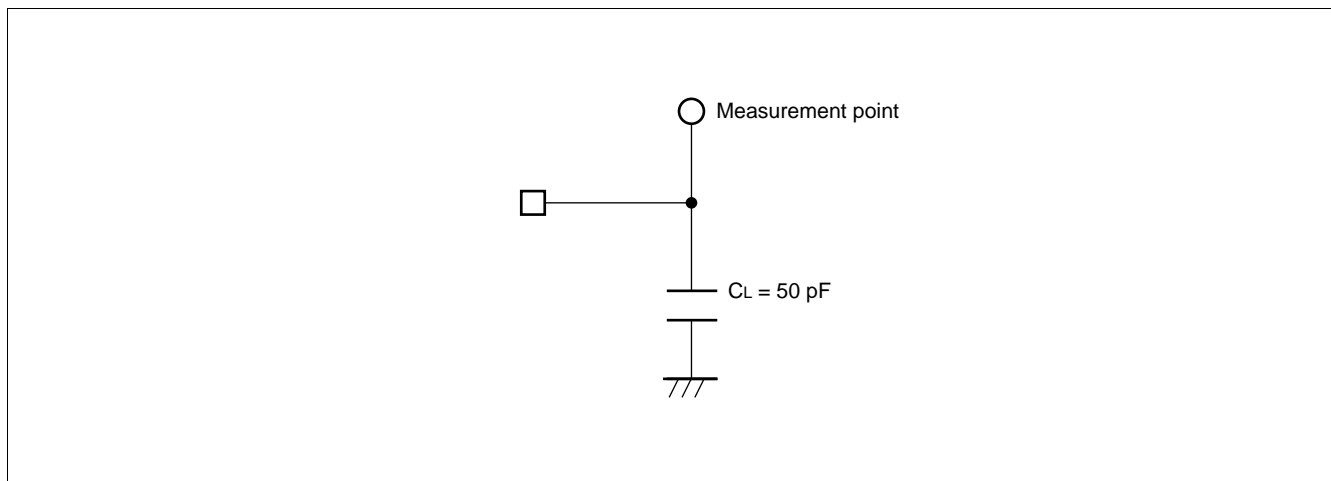
( $V_{REF}, V_{CC} = 3.3\text{ V to }+5.5\text{ V}$  ( $V_{CC} \geq V_{REF}$ ),  $A_{GND} = 0\text{ V}$ ,  $T_a = -40^\circ\text{C to }+85^\circ\text{C}$ )

Parameter	Symbol	Conditions	Value		Unit
			Min	Max	
Clock cycle time	$t_{CLK}$	$V_{CC} = 5\text{ V} \pm 10\%$ *1	1.0	30.0	$\mu\text{S}$
		—	6.0	30.0	$\mu\text{S}$
Low-level clock pulse width	$t_{CKL}$	—	2.8	14.8	$\mu\text{S}$
High-level clock pulse width	$t_{CKH}$	—	2.8	14.8	$\mu\text{S}$
Clock rise time Clock fall time	$t_{Cr}$ $t_{Cf}$	—	—	0.2	$\mu\text{S}$
$\overline{\text{CS}}$ setup time	$t_{CSS}$	—	$t_{CKL} + 0.4$	—	$\mu\text{S}$
$\overline{\text{CS}}$ hold time	$t_{CSH}$	—	1.0	—	$\mu\text{S}$
$\overline{\text{CS}}$ release time	$t_{CSR}$	—	1.0	—	CLK
Channel setup time	$t_{CHS}$	—	0	—	$\mu\text{S}$
Channel hold time	$t_{CHH}$	—	1.0	—	CLK
Data output delay time	$t_{DO}$	*2	—	0.5	$\mu\text{S}$
MOD setup time	$t_{MOS}$	—	0.2	—	$\mu\text{S}$
MOD hold time	$t_{MOH}$	—	0.1	—	$\mu\text{S}$
Data active delay time	$t_{DVE}$	—	—	0.5	$\mu\text{S}$
Data float delay time	$t_{DZE}$	—	—	0.5	$\mu\text{S}$
SAMP active delay time	$t_{SVE}$	—	—	0.5	$\mu\text{S}$
SAMP float delay time	$t_{SZE}$	—	—	0.5	$\mu\text{S}$
SAMP high-level output delay time	$t_{SHD}$	*2	—	0.5	$\mu\text{S}$
SAMP low-level output delay time	$t_{SLD}$	*2	—	0.5	$\mu\text{S}$

\*1: Depending on the output impedance of the external circuit connected to the analog input pin

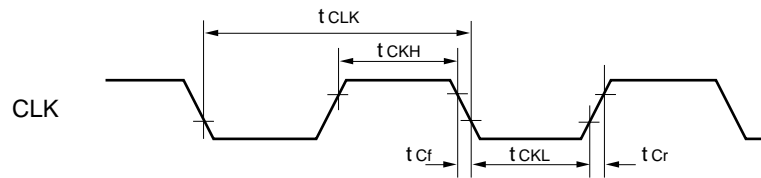
\*2: See “• AC test circuit.”

### • AC test circuit



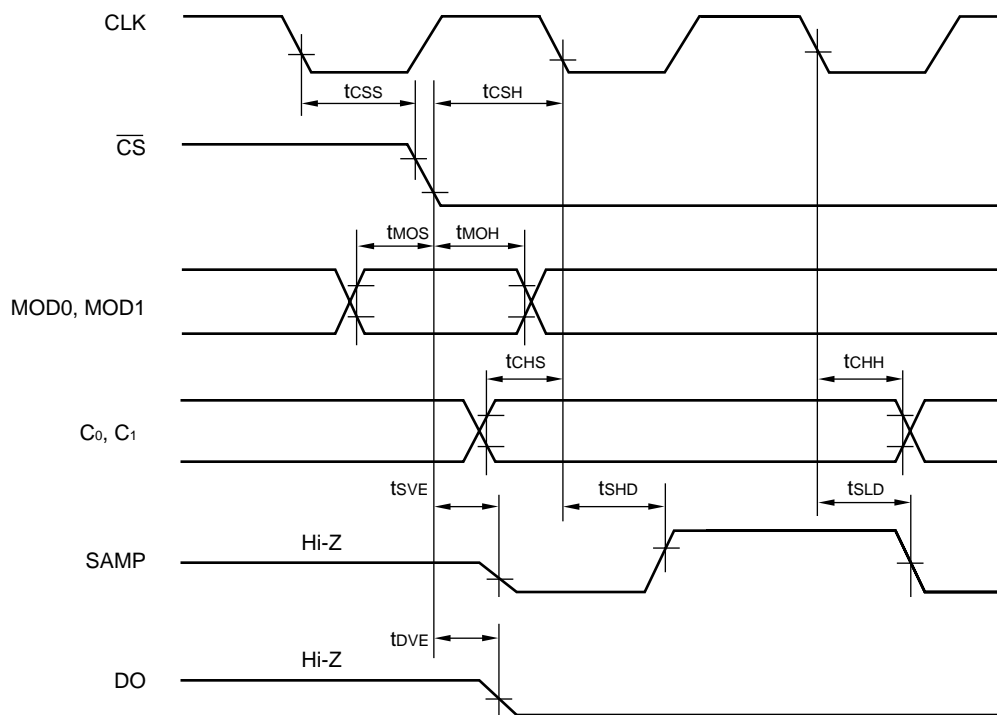
## ■ TIMING DIAGRAM

### (1) Input clock timing



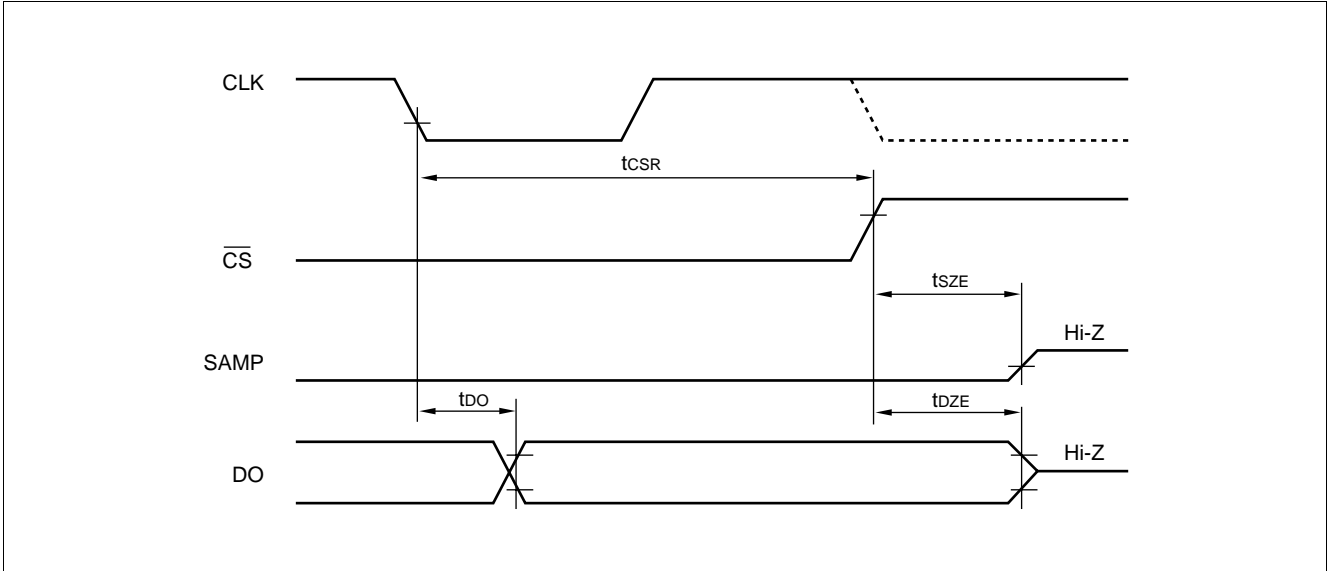
Evaluation levels are 80% and 20% of the  $V_{CC}$ .

### (2) A/D startup timing

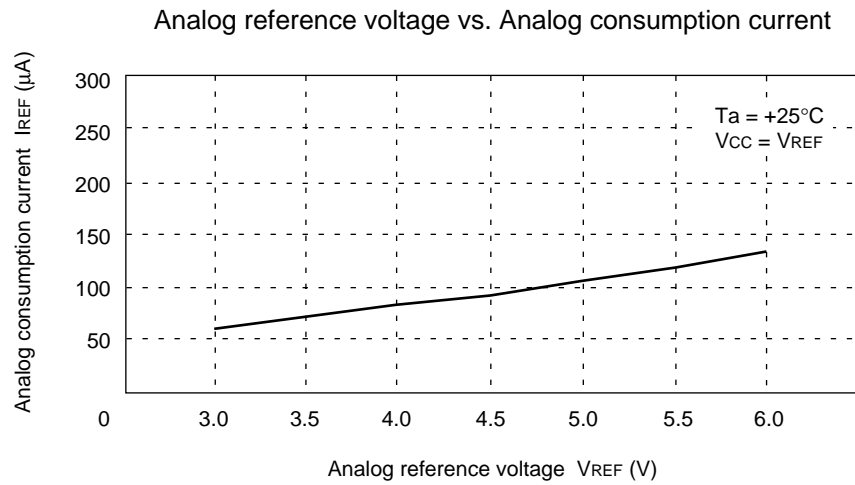
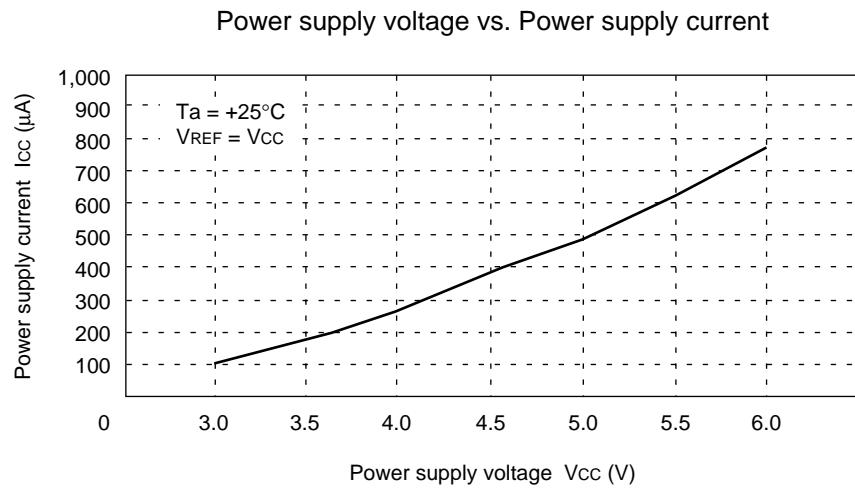


# MB88101A

## (3) Data output delay time and A/D stop timing



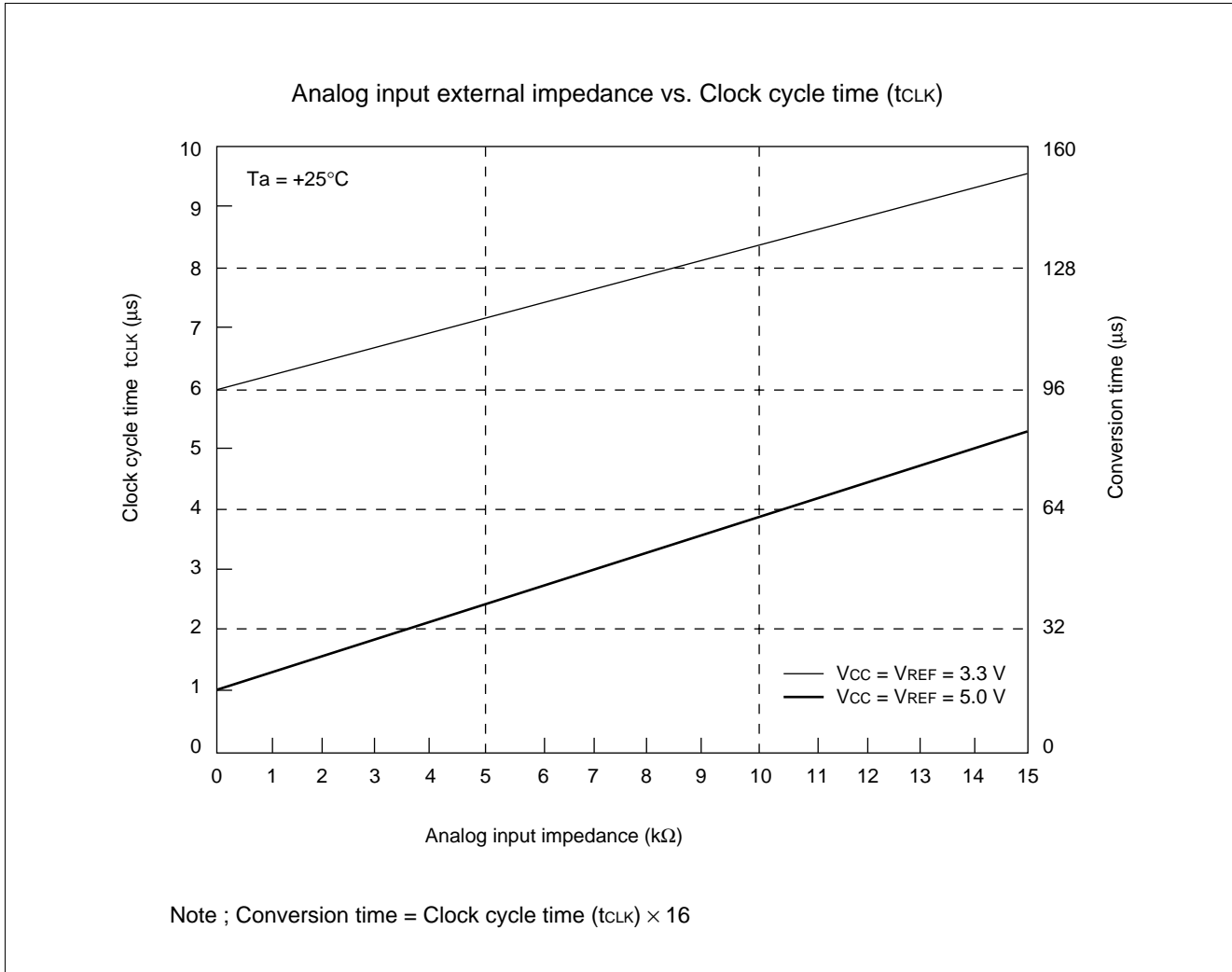
## ■ TYPICAL CHARACTERISTICS



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# MB88101A

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## ■ ORDERING INFORMATION

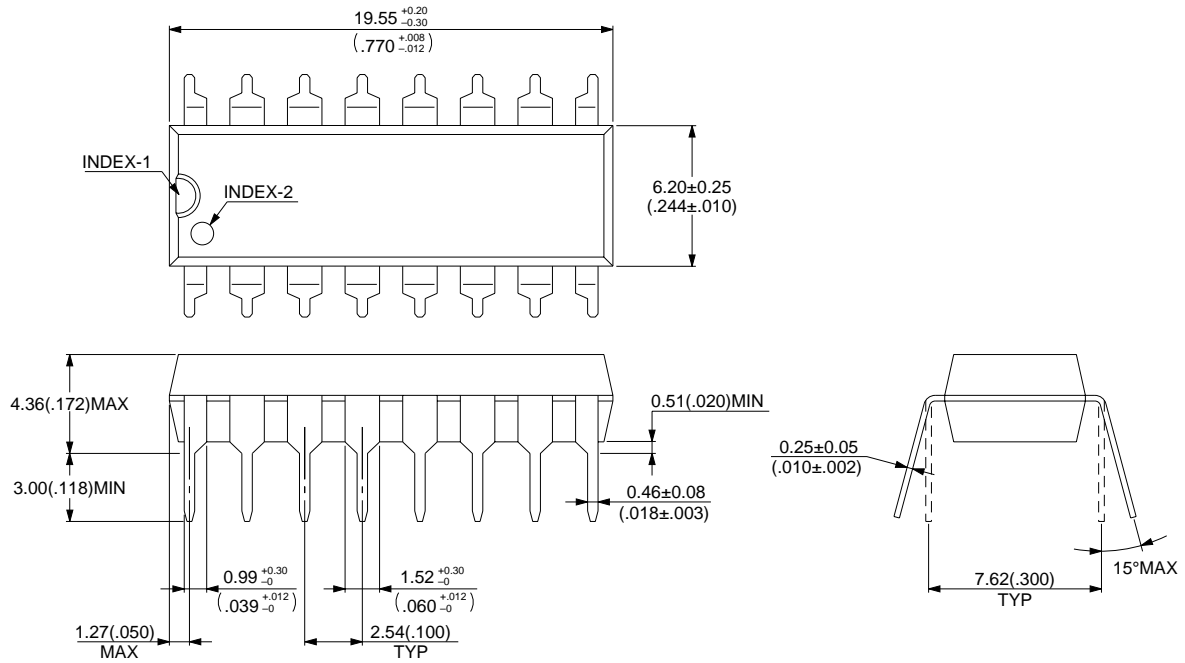
Part number	Package	Remarks
MB88101AP	16-pin Plastic DIP (DIP-16P-M04)	
MB88101APFV	16-pin Plastic SSOP (FPT-16P-M05)	
MB88101APF	16-pin Plastic SOP (FPT-16P-M06)	



# MB88101A

## ■ PACKAGE DIMENSIONS

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



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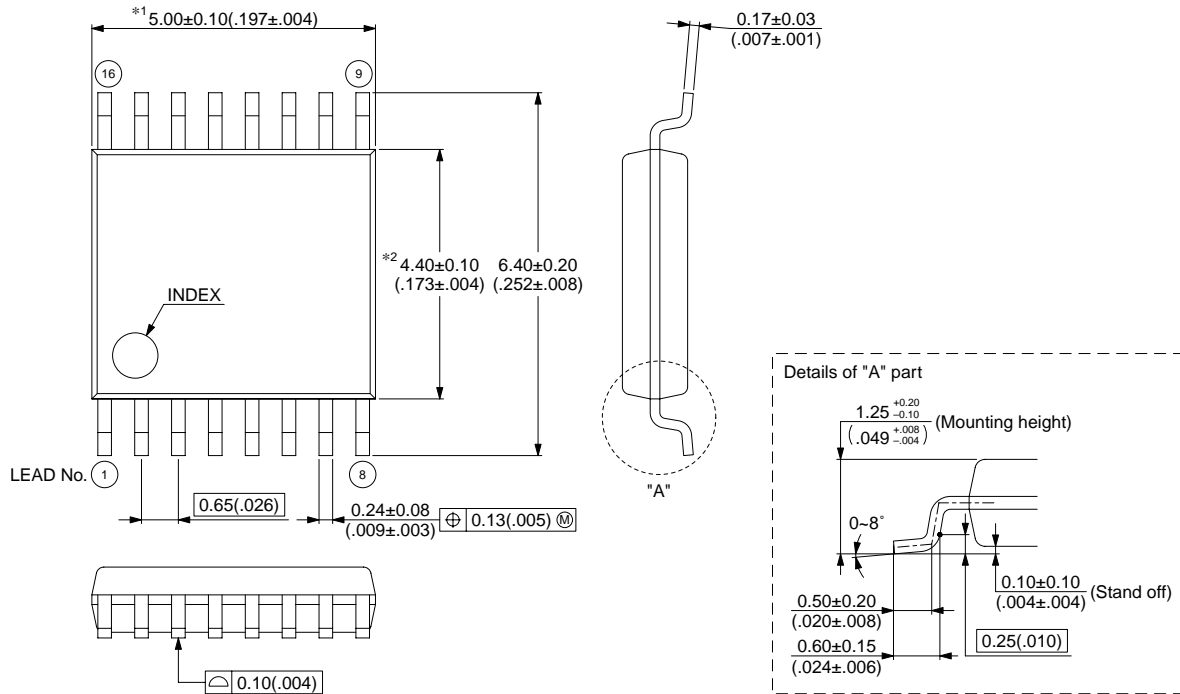
Dimensions in mm (inches) .

Note : The values in parentheses are reference values.

(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.



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Dimensions in mm (inches) .

Note : The values in parentheses are reference values.

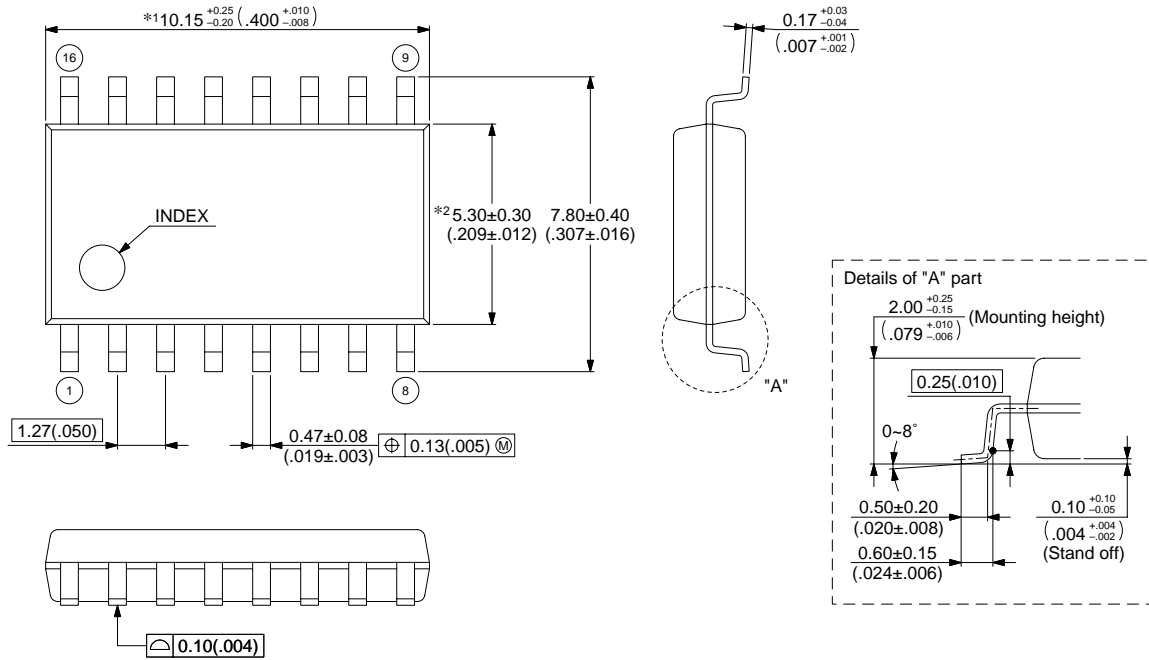
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# MB88101A

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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.



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Dimensions in mm (inches) .

Note : The values in parentheses are reference values.

**MEMO**



# FUJITSU MICROELECTRONICS LIMITED

Shinjuku Dai-Ichi Seimei Bldg. 7-1, Nishishinjuku 2-chome, Shinjuku-ku,  
Tokyo 163-0722, Japan Tel: +81-3-5322-3347 Fax: +81-3-5322-3387  
<http://jp.fujitsu.com/fml/en/>

*For further information please contact:*

## **North and South America**

FUJITSU MICROELECTRONICS AMERICA, INC.  
1250 E. Arques Avenue, M/S 333  
Sunnyvale, CA 94085-5401, U.S.A.  
Tel: +1-408-737-5600 Fax: +1-408-737-5999  
<http://www.fma.fujitsu.com/>

## **Europe**

FUJITSU MICROELECTRONICS EUROPE GmbH  
Pittlerstrasse 47, 63225 Langen,  
Germany  
Tel: +49-6103-690-0 Fax: +49-6103-690-122  
<http://emea.fujitsu.com/microelectronics/>

## **Korea**

FUJITSU MICROELECTRONICS KOREA LTD.  
206 KOSMO TOWER, 1002 Daechi-Dong,  
Kangnam-Gu, Seoul 135-280  
Korea  
Tel: +82-2-3484-7100 Fax: +82-2-3484-7111  
<http://www.fmk.fujitsu.com/>

## **Asia Pacific**

FUJITSU MICROELECTRONICS ASIA PTE LTD.  
151 Lorong Chuan, #05-08 New Tech Park,  
Singapore 556741  
Tel: +65-6281-0770 Fax: +65-6281-0220  
<http://www.fujitsu.com/sg/services/micro/semiconductor/>

FUJITSU MICROELECTRONICS SHANGHAI CO., LTD.  
Rm.3102, Bund Center, No.222 Yan An Road(E),  
Shanghai 200002, China  
Tel: +86-21-6335-1560 Fax: +86-21-6335-1605  
<http://cn.fujitsu.com/fmc/>

FUJITSU MICROELECTRONICS PACIFIC ASIA LTD.  
10/F., World Commerce Centre, 11 Canton Road  
Tsimshatsui, Kowloon  
Hong Kong  
Tel: +852-2377-0226 Fax: +852-2376-3269  
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