FUJITSU SEMICONDUCTOR
DATA SHEET

DS04-13105-2E

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.

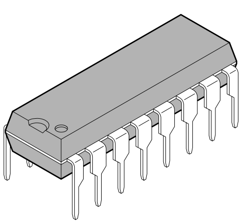
The MB88101A can be switched to a mode for continuous A/D conversion, in which it outputs serial data from the MSB or LSB selectable depending on the mode setting.

■ 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, SSOP, and SOP available

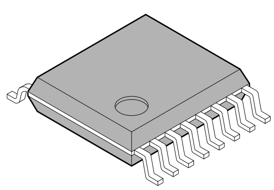
■ PACKAGES

16-pin Plastic DIP



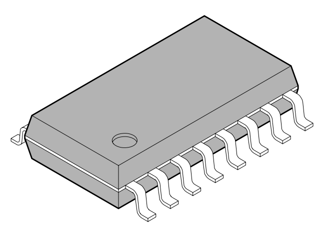
(DIP-16P-M04)

16-pin Plastic SSOP



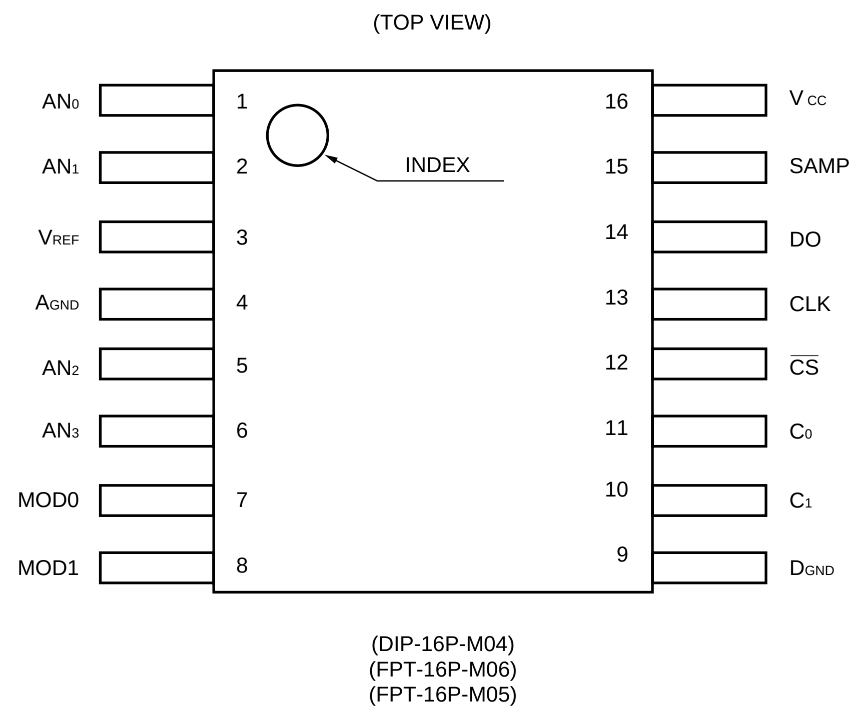
(FPT-16P-M05)

16-pin Plastic SOP



(FPT-16P-M06)

■ PIN ASSIGNMENT



■ PIN DESCRIPTION

Pin no.	Symbol	I/O	Descriptions
1 2 5 6	AN_0 AN_1 AN_2 AN_3	I	Analog input pins. One of these channels can be selected depending on the C_0 and C_1 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_0 C_1	I	Input pins for selecting the analog input channels from among pins AN_0 to AN_3. 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 three clock cycles after the signal level at this pin goes “L” after “H” for one clock cycle.
3	V_{REF}	—	Reference voltage input pin
4	A_{GND}	—	Analog circuit ground pin
9	D_{GND}	—	Digital circuit ground pin
16	V_{CC}	—	Power supply pin

• **Channel selection**

Table 1 Pin Settings and Channel Selection

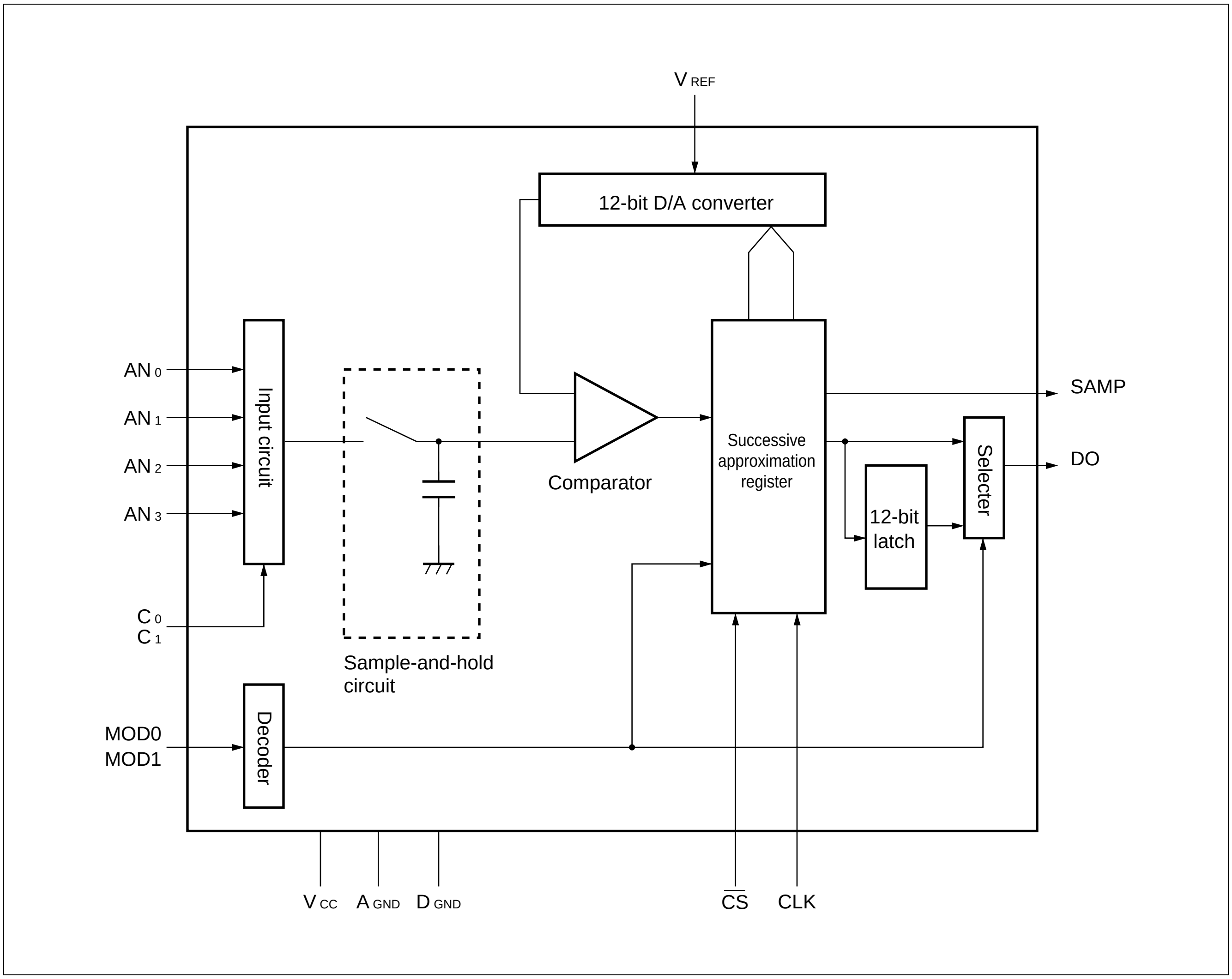
C_1	C_0	Channel
L	L	AN_0
L	H	AN_1
H	L	AN_2
H	H	AN_3

• **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

■ BLOCK DIAGRAM

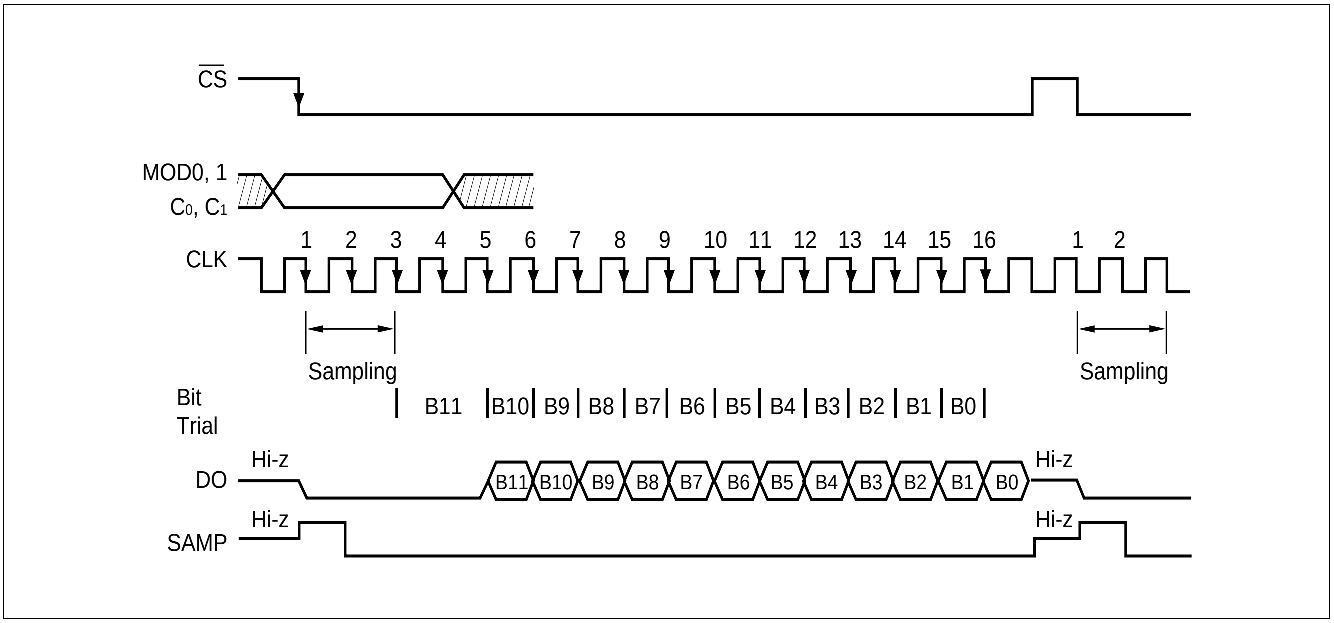


■ FUNCTIONAL DESCRIPTION

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.

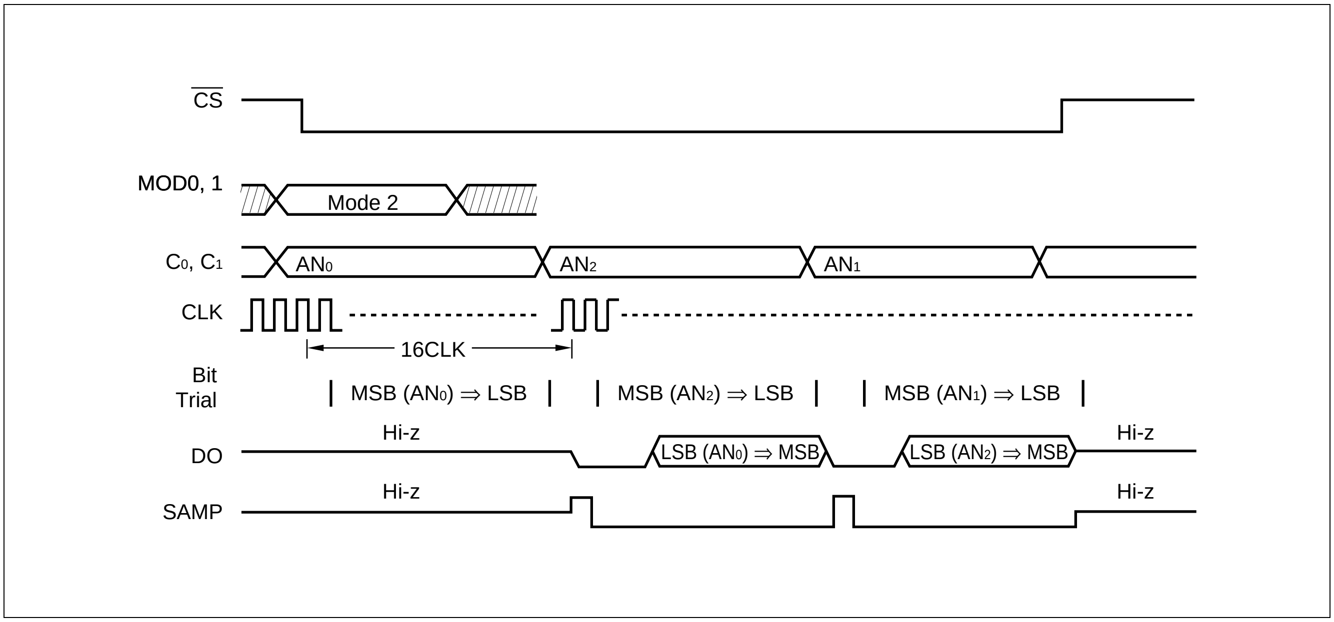
- **Timing diagram**



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.

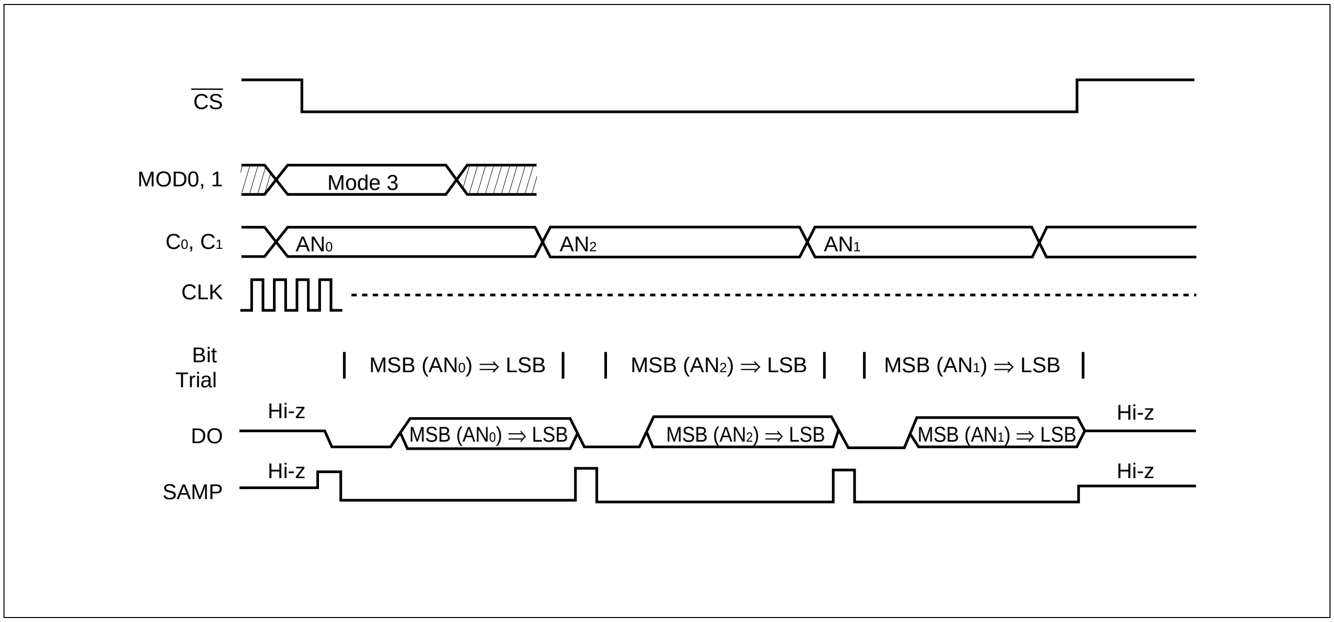
- **Timing diagram**



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_{CC}	Based on GND (Ta = +25°C)	–0.3	+7.0	V
	V_{REF}		–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	—	—	150	mW
Operating temperature	Ta	—	–20	+85	°C
Storage temperature	T_{stg}	—	–55	+150	°C

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

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_{CC}	3.3	—	5.5	V
	GND	—	0	—	V
Operation 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 CHARACTERISTIC

1. DC Characteristics

(1) Digital section

(V_{CC} = 3.3 V to 5.5 V, D_{GND} = 0 V, Ta = –20°C to +85°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}	V_{CC}	Operation at CLK =166kHz (with no load)	—	0.8	2.0	mA
Input leakage current	I_{ILK}	MOD0, 1, $\overline{CLK}$, $\overline{CS}$, C_0, C_1	V_{IN} = 0 to V_{CC}	–10	—	10	µA
Low-level input voltage	V_{IL}	MOD0, 1, $\overline{CLK}$, $\overline{CS}$, C_0, C_1	—	V_{SS} – 0.3	—	0.2 V_{CC}	V
High-level input voltage	V_{IH}	MOD0, 1, $\overline{CLK}$, $\overline{CS}$, C_0, C_1	—	0.8 V_{CC}	—	V_{CC} + 0.3	V
High-impedance output leakage current	I_{OLZ}	DO, SAMP	V_{IN} = 0 to V_{CC}	–10	—	10	µA
Low-level output voltage	V_{OL}	DO, SAMP	I_{OL} = 2.5 mA	—	—	0.4	V
High-level output voltage	V_{OH}	DO, SAMP	I_{OH} = –400 µA	V_{CC} – 0.4	—	—	V

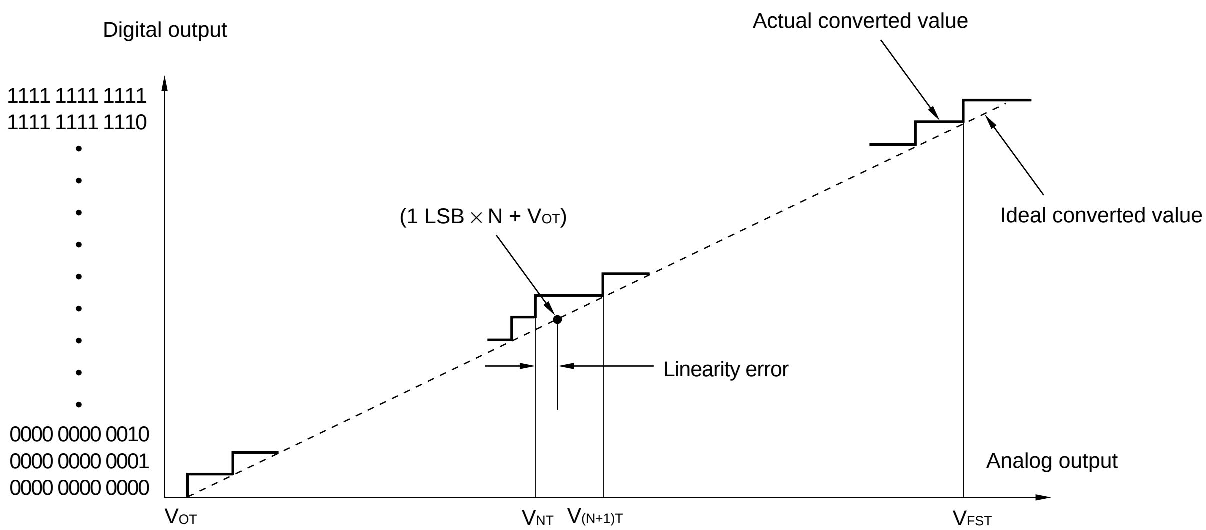
(2) Analog section

(V_{REF}, V_{CC} = 3.3 V to 5.5 V ($V_{CC} \geq V_{REF}$), A_{GND} = 0 V, Ta = –20°C to +85°C)

Parameter	Symbol	Pin name	Value			Unit
			Min.	Typ.	Max.	
Resolution	—	AN_0 to AN_3	—	12	—	bits
Linearity error	—	AN_0 to AN_3	–4.0	—	2.0	LSB
Differential linearity error	—	AN_0 to AN_3	–1.0	—	3.0	LSB
Conversion time	—	—	—	16	—	CLK
Consumption current	I_{REF}	V_{REF}	—	100	300	µA
Analog reference voltage	—	V_{REF}	3.3	5.0	V_{CC}	V
Analog input voltage	—	AN_0 to AN_3	0	—	V_{REF}	V

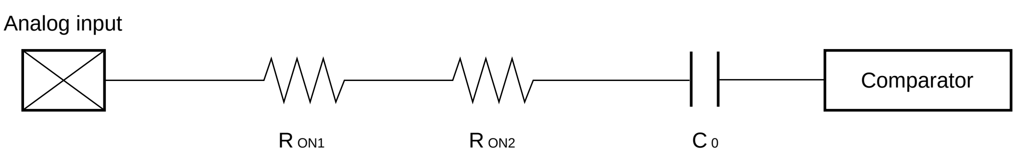
(3) Definitions of A/D converter terms

- 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



- 1 LSB $= \dfrac{V_{FST} - V_{OT}}{4094}$
- Linearity error $= \dfrac{V_{NT} - (1\ \text{LSB} \times N + V_{OT})}{1\ \text{LSB}}$ (LSB)
- Differential linearity error $= \dfrac{V_{(N+1)T} - V_{NT}}{1\ \text{LSB}} - 1$ (LSB)

- **Analog input equivalent circuit**



· R_{ON1} = About 1.5 kΩ
· R_{ON2} = About 1.5 kΩ
· C_0 = 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 V_{REF} on.

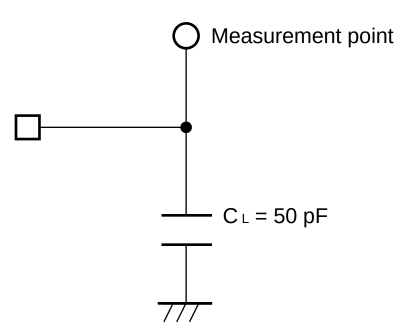
2. AC Characteristics

(V_{REF}, V_{CC} = 3.3 V to +5.5 V ($V_{CC} \geq V_{REF}$), A_{GND} = 0 V, Ta = –20°C to +85°C)

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

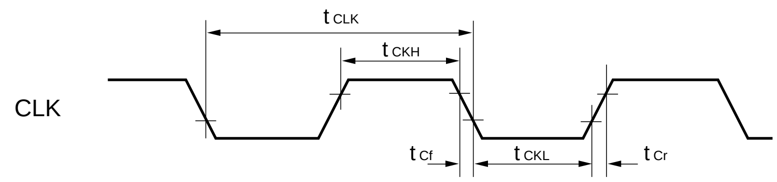
*1: Depending on the output impedance of the external circuit connected to the analog input pin
*2: See "• AC test circuit."

- **AC test circuit**



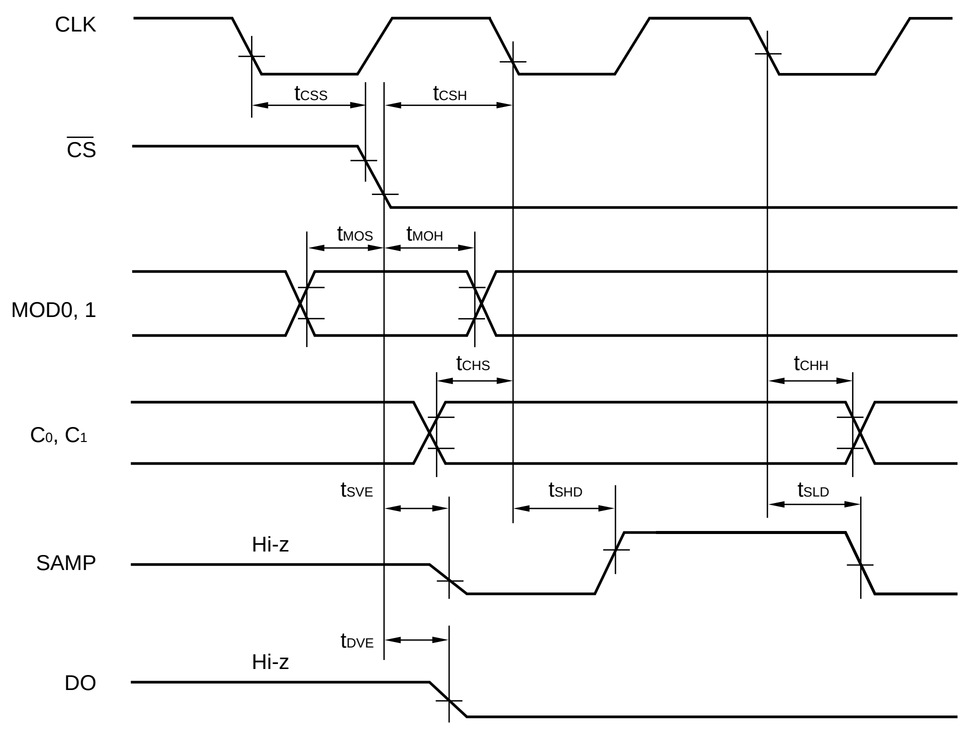
■ TIMING DIAGRAM

(1) Input clock timing

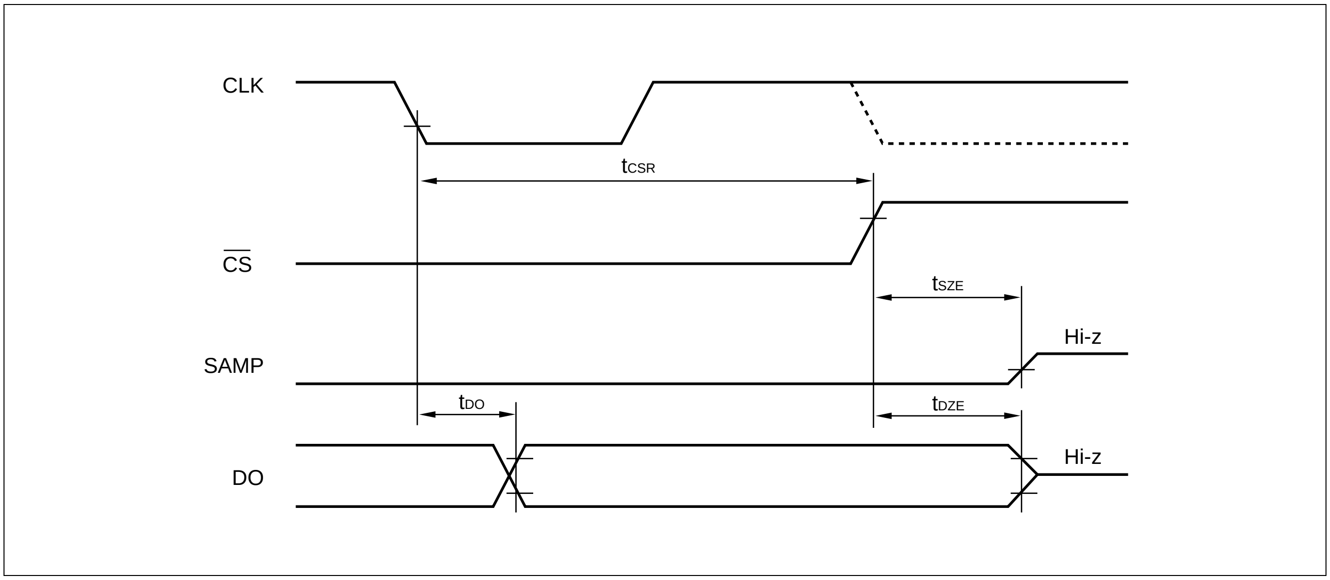


Evaluation levels are 80% and 20% of the V_{CC}.

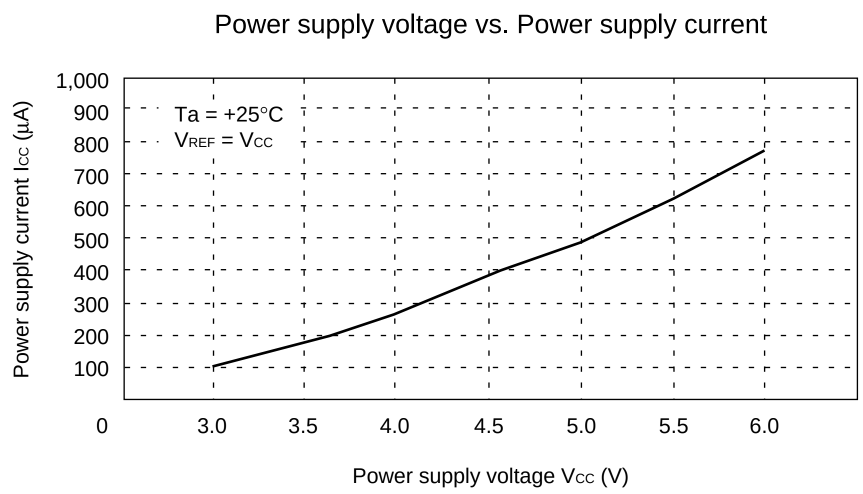
(2) A/D startup timing

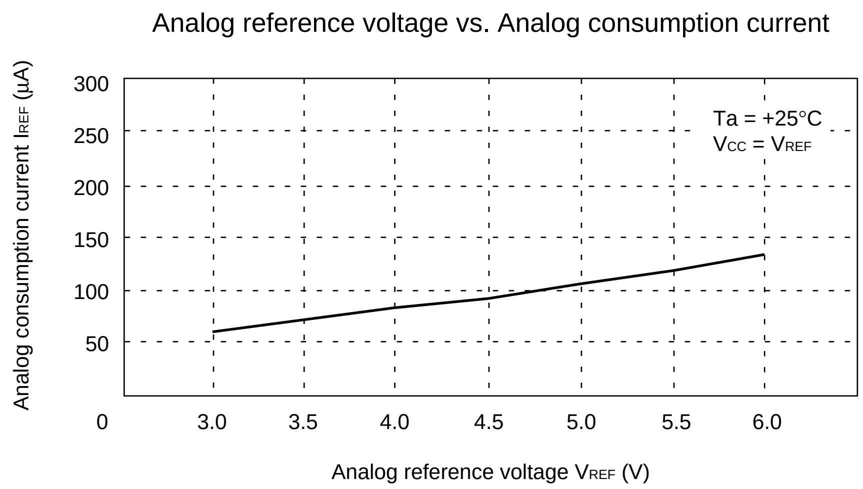


(3) Data output delay time and A/D stop timing

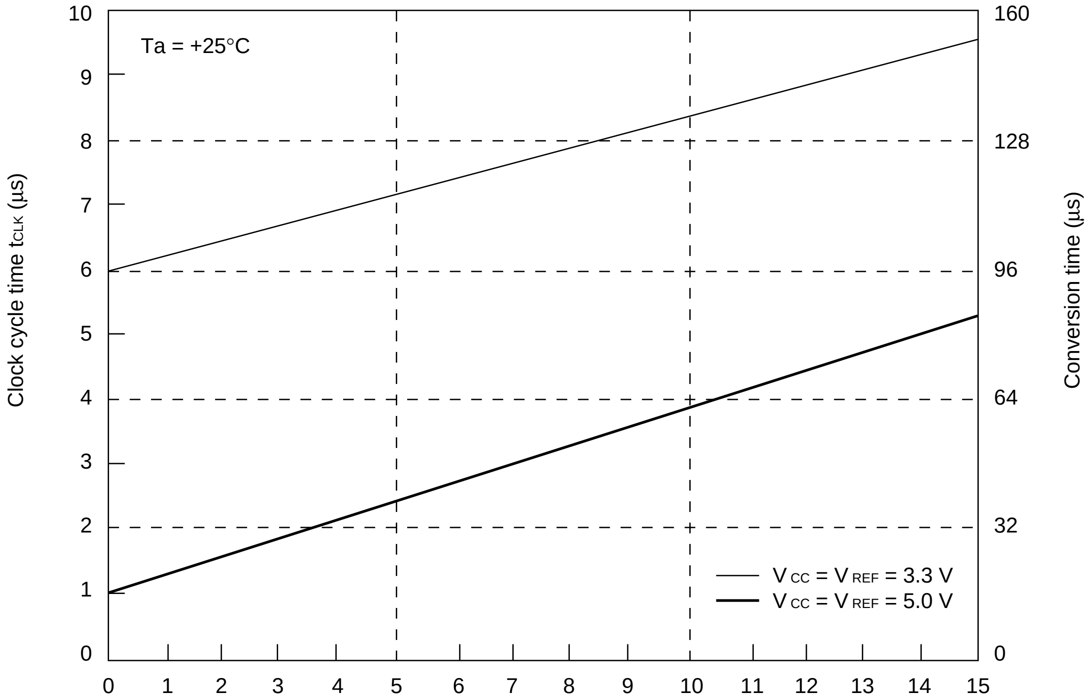


■ TYPICAL CHARACTERISTICS





Analog input external impedance vs. Clock cycle time (t_{CLK})



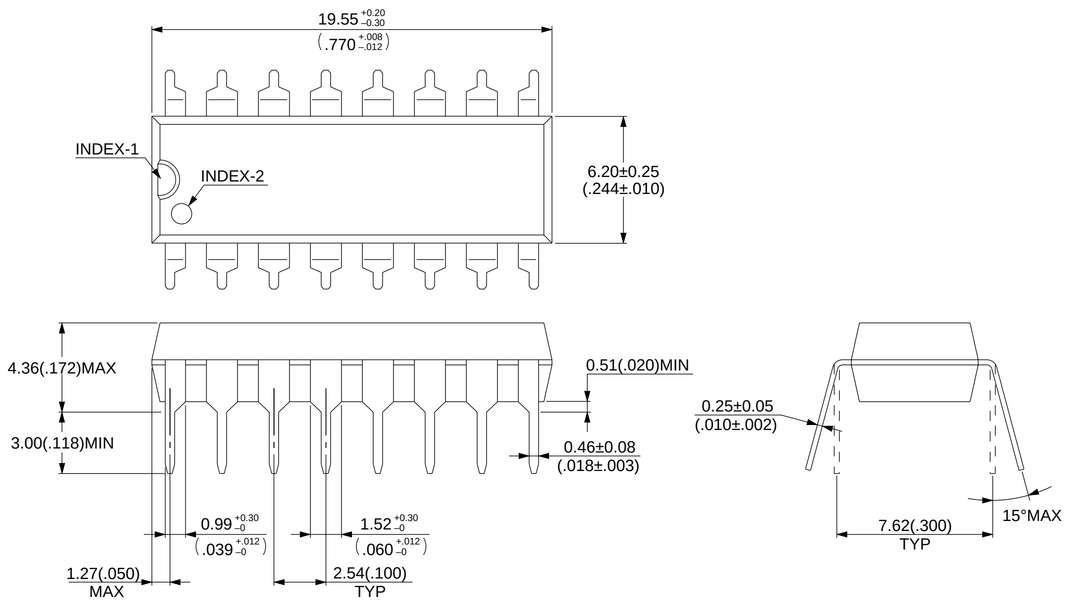
Analog input impedance (kΩ)
Conversion time = Clock cycle time (t_{CLK}) × 16

■ 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)	

■ PACKAGE DIMENSIONS

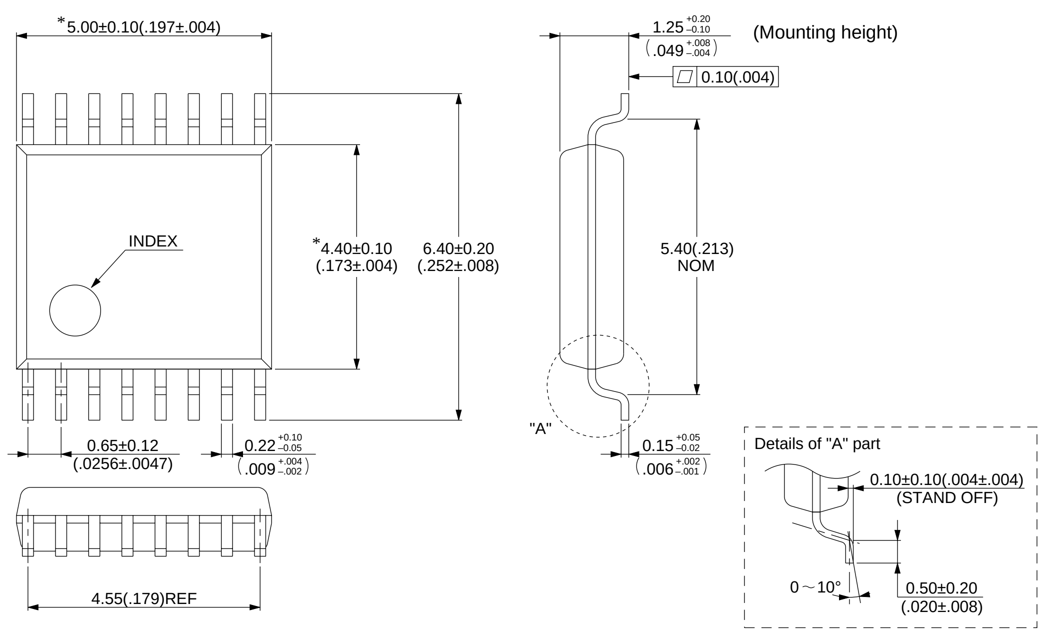
16-pin Plastic DIP
(DIP-16P-M04)



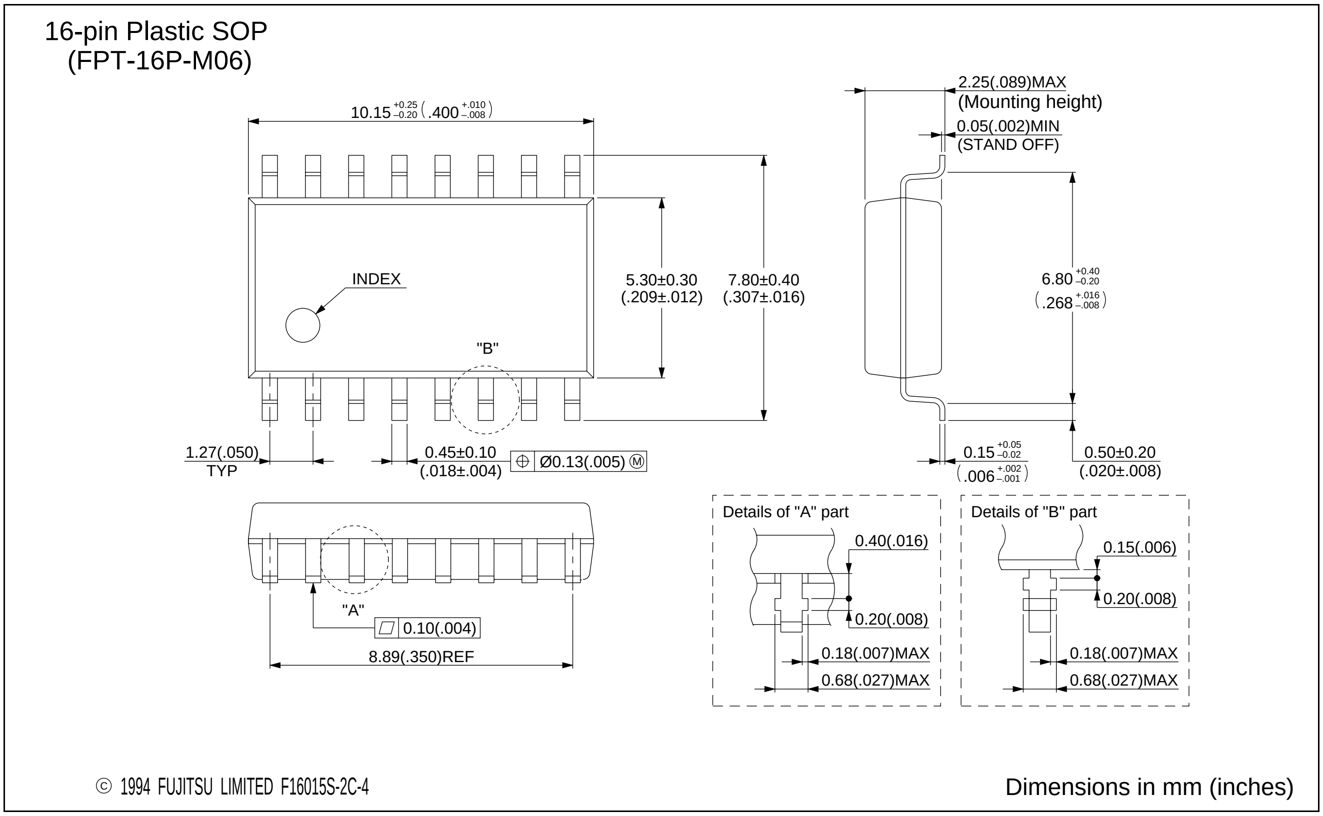
Dimensions in mm (inches)

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

*: This dimension do not include resin protrusion.



Dimensions in mm (inches)



16-pin Plastic SOP
(FPT-16P-M06)
10.15 +0.25 −0.20 (.400 +.010 −.008)
2.25(.089)MAX
(Mounting height)
0.05(.002)MIN
(STAND OFF)
INDEX
5.30±0.30
(.209±.012)
7.80±0.40
(.307±.016)
6.80 +0.40 −0.20
(.268 +.016 −.008)
"B"
1.27(.050)
TYP
0.45±0.10
(.018±.004)
Ø0.13(.005) Ⓜ
0.15 +0.05 −0.02
(.006 +.002 −.001)
0.50±0.20
(.020±.008)
"A"
0.10(.004)
8.89(.350)REF
Details of "A" part
0.40(.016)
0.20(.008)
0.18(.007)MAX
0.68(.027)MAX
Details of "B" part
0.15(.006)
0.20(.008)
0.18(.007)MAX
0.68(.027)MAX
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Dimensions in mm (inches)

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