FUJITSU SEMICONDUCTOR
DATA SHEET

DS04-13506-3E

Linear IC General purpose Converter

CMOS

D/A Converter for Digital Tuning
(8 channels. 8-bit, with OP amplifier)

MB88347

■ DESCRIPTION

The MB88347 features 8 channels of 8-bit D/A converters (with output amplifiers). The output amplifier provides high current drive capability. As data is input via a serial link, only three control lines are required, and cascaded connections can be used.

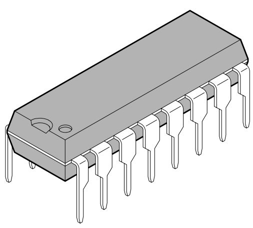
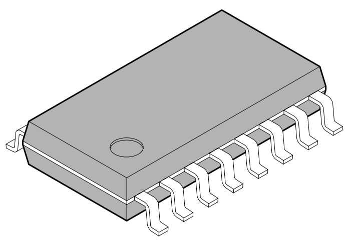
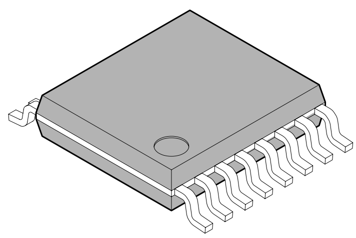
The MB88347 is suitable for electronic volumes and replacement for potentiometers for adjustment, in addition to normal D/A converter applications.

■ FEATURES

- Low power consumption (2 mW/ch)
- Small package
- Integrating 8 channels of R-2R type 8-bit D/A converter.

(Continued)

■ PACKAGES

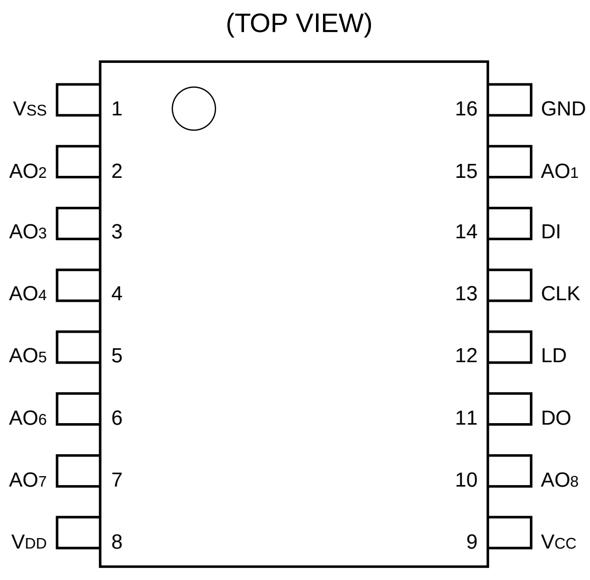
16-pin plastic DIP	16-pin plastic SOP	16-pin plastic SSOP
		
(DIP-16P-M04)	(FPT-16P-M06)	(FPT-16P-M05)

FUJITSU

(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 16-pin, SOP 16-pin, SSOP 16-pin

■ PIN ASSIGNMENT



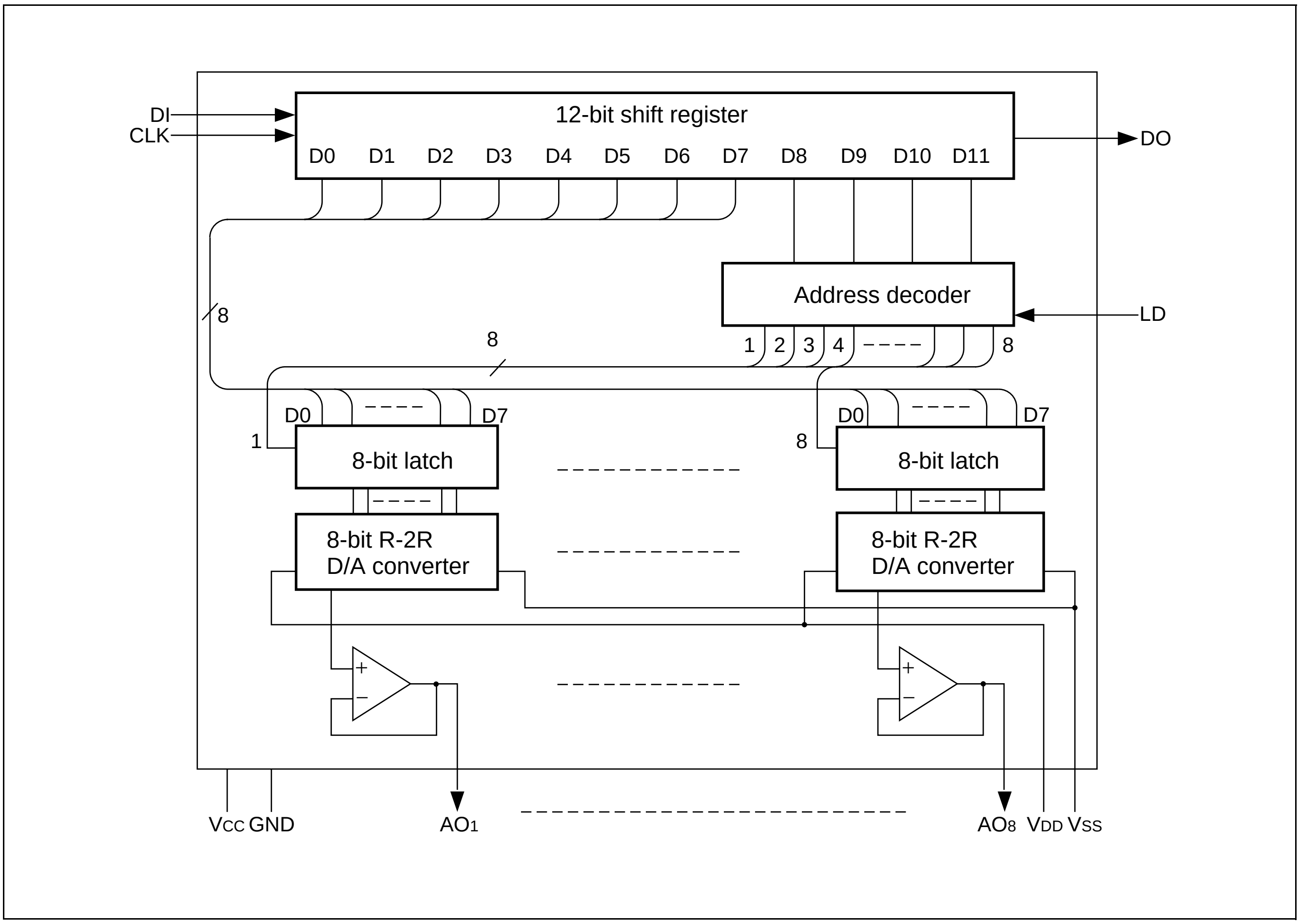
(DIP-16P-M04)
(FPT-16P-M06)
(FPT-16P-M05)

■ PIN DESCRIPTION

Pin No.	Symbol	I/O	Pin name	Function
14	DI*	I	Data input pin	Serial data input pin. This pin inputs 12-bit length serial data.
11	DO	O	Data output pin	This pin outputs MSB bit data of 12-bit shift register.
13	CLK*	I	Shift clock input pin	Shift clock input pin. The input signal from the DI pin is inputted to a 12-bit shift register on the rising edge of the shift clock.
12	LD*	I	Load signal input pin	If input “H” level to LD pin, the data of shift register is loaded to the decoder and the register for D/A output.
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	D/A output pin	These pins are 8-bit D/A output with OP amplifier.
9	V_{CC}	—	Power supply pin	Power supply pin of MCU interface and OP amplifier
16	GND	—	Ground pin	Ground pin of MCU interface and OP amplifier
8	V_{DD}	—	Power supply pin	Power supply pin of D/A converter
1	V_{SS}	—	Ground pin	Ground pin of D/A converter

* : DI, CLK, and LD pins are fixed to “L” level at non transfer.

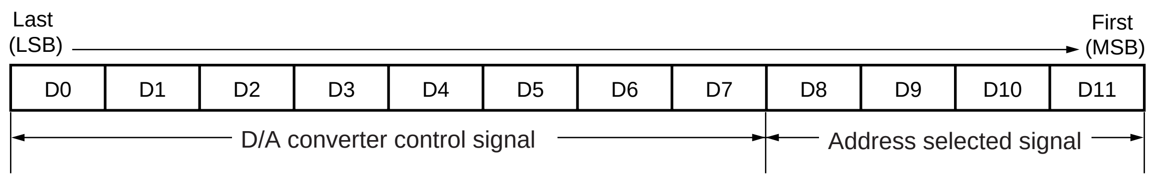
■ BLOCK DIAGRAM



■ DATA FOR CHIP CONTROL

1. Data for Shift Register

- MB88347 has 12-bit shift register for chip control.
- It is necessary to set the data as following configuration to 12-bit shift register.
- The data consists of 12 bits: a 4-bit address selection and an 8-bit D/A converter control signal.



2. D/A Converter Control Signal

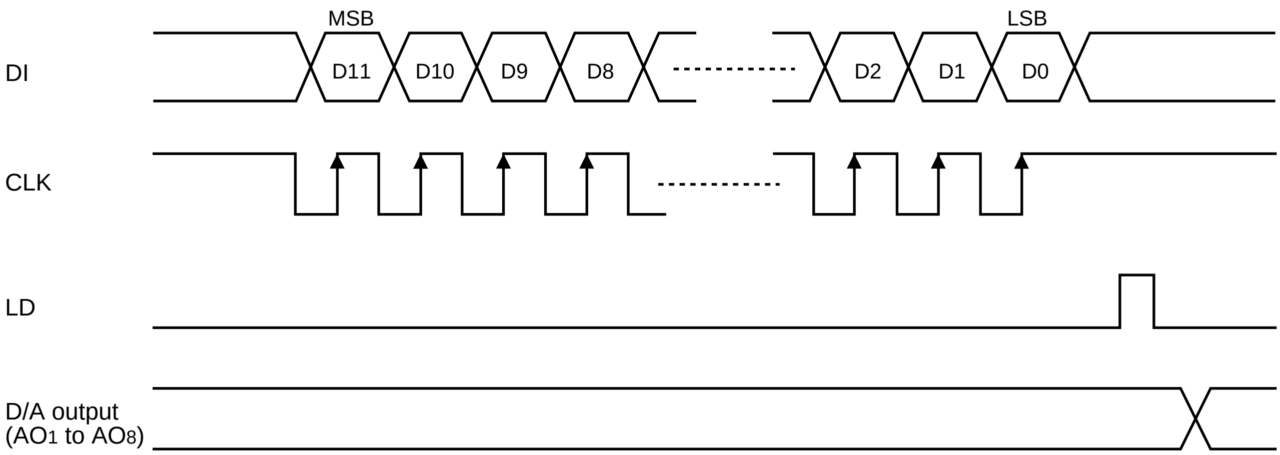
Input data signal								D/A converter output voltage
D0	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	
0	0	0	0	0	0	0	0	$\fallingdotseq V_{SS}$
1	0	0	0	0	0	0	0	$\fallingdotseq V_{LB} + V_{SS}$
0	1	0	0	0	0	0	0	$\fallingdotseq V_{LB} \times 2 + V_{SS}$
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
0	1	1	1	1	1	1	1	$\fallingdotseq V_{LB} \times 254 + V_{SS}$
1	1	1	1	1	1	1	1	$\fallingdotseq V_{DD}$

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

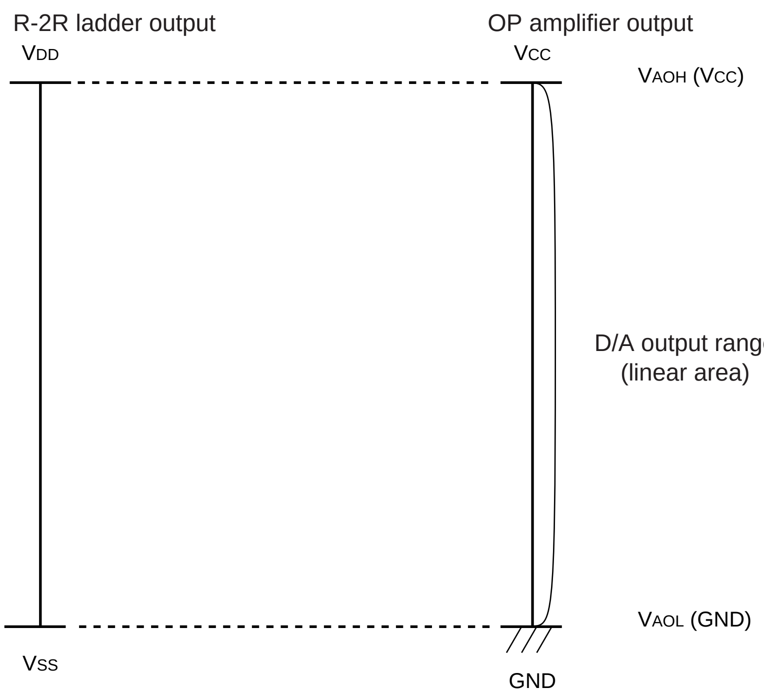
3. Address Selected Signal

Input data signal				Address selected
D8	D9	D10	D11	
0	0	0	0	Don't Care
0	0	0	1	AO_1 selected
0	0	1	0	AO_2 selected
0	0	1	1	AO_3 selected
0	1	0	0	AO_4 selected
0	1	0	1	AO_5 selected
0	1	1	0	AO_6 selected
0	1	1	1	AO_7 selected
1	0	0	0	AO_8 selected
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

■ TIMING CHART AT DATA SETTING



■ ANALOG OUTPUT VOLTAGE RANGE



Note : $V_{CC} = V_{DD}$, $GND = V_{SS}$

■ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Condition	Rating		Unit
			Min	Max	
Power supply voltage	V_{CC}	The case that GND is reffered. 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	—	– 40	+ 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	Max	
Power supply Voltage 1	V_{CC}	—	4.5	5.5	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}	—	—	1.0	mA
Analog output sink current	I_{AH}	—	—	1.0	mA
Oscillation limited output capacitance	C_{OL}	—	—	1.0	µF
Digital data setting range	—	—	#00	#FF	—
Operating temperature	Ta	—	– 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 FUJITSU representatives beforehand.

■ ELECTRICAL CHARACTERISTICS

1. DC Characteristics

(1) Digital block

(V_{DD}, V_{CC} = +5 V ± 10% ($V_{CC} \geq V_{DD}$) , GND, V_{SS} = 0 V, Ta = −40 °C to +85 °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}	V_{CC}	At CLK = 1 MHz operating (at no load) At Ta = −20 °C to +85 °C	—	0.8	1.8	mA
			At CLK = 1 MHz operating (at no load) At Ta = −40 °C to +85 °C	—	0.8	2.1	mA
Input leakage 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}		—	0.5 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

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

(2) Analog block

(V_{DD}, V_{CC} = + 5 V ± 10% ($V_{CC} \geq V_{DD}$) , GND, V_{SS} = 0 V, Ta = – 40 °C to + 85 °C)

Parameter	Symbol	Pin name	Conditions	Value			Unit
				Min	Typ	Max	
Consumption current	I_{DD}	V_{DD}	No load	—	1.0	1.5	mA
Analog power supply voltage	V_{DD}	V_{DD}	$V_{DD} - V_{SS} \geq 2.0$ V	2.0	—	V_{CC}	V
	V_{SS}	V_{SS}		GND	—	$V_{CC} - 2.0$	V
Resolution	Res	AO_1 to AO_8	—	—	8	—	bit
Monotonic increase	Rem		No load $V_{DD} \leq V_{CC} - 0.1$ V $V_{SS} \geq 0.1$ V	—	8	—	bit
Non linearity error*1	LE			–1.5	—	1.5	LSB
Differential linearity error*2	D_{LE}			–1.0	—	1.0	LSB
Output minimum voltage 1	V_{AOL1}	AO_1 to AO_8	$V_{DD} = V_{CC}$ 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}		$V_{DD} = V_{CC}$ = 5.0 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}		$V_{DD} = V_{CC}$ = 5.0 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}		$V_{DD} = V_{CC}$ = 5.0 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}		$V_{DD} = V_{CC}$ = 5.0 V V_{SS} = GND = 0.0 V I_{AH} = 1.0 mA Digital data = #00	V_{SS}	—	$V_{SS} + 0.3$	V

(Continued)

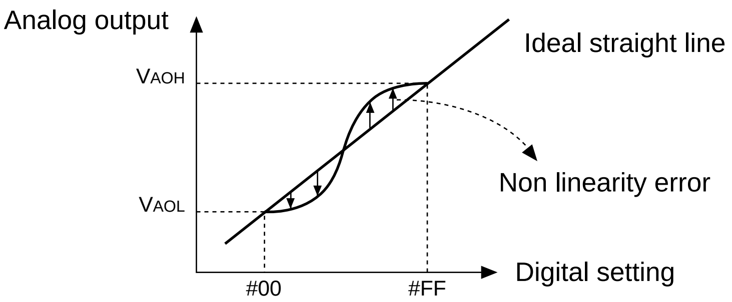
(Continued)

(V_{DD}, V_{CC} = + 5 V ± 10% ($V_{CC} \geq V_{DD}$) , GND, V_{SS} = 0 V, Ta = – 40 °C to + 85 °C)

Parameter	Symbol	Pin name	Conditions	Value			Unit
				Min	Typ	Max	
Output maximum voltage 1	V_{AOH1}	AO_1 to AO_8	$V_{DD} = V_{CC}$ 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}		$V_{DD} = V_{CC}$ = 5.0 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}		$V_{DD} = V_{CC}$ = 5.0 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}		$V_{DD} = V_{CC}$ = 5.0 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}		$V_{DD} = V_{CC}$ = 5.0 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

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

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



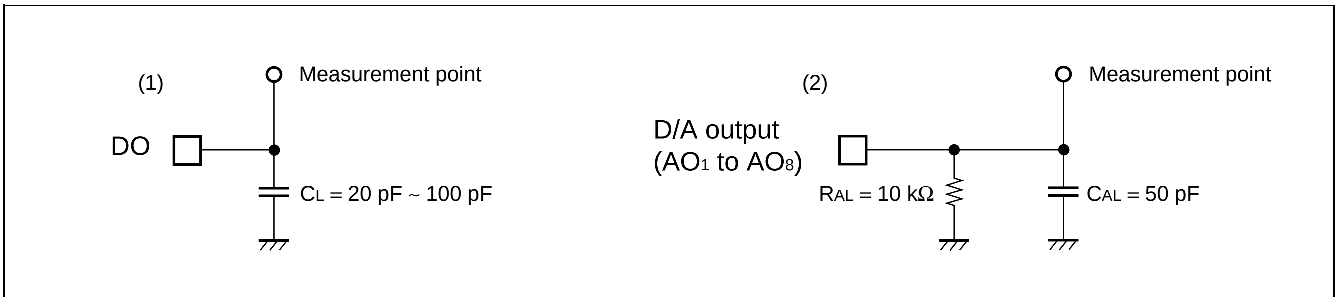
Note: V_{AOH} and V_{AOL} do not always match V_{DD} and V_{SS}, respectively.

2. AC Characteristics

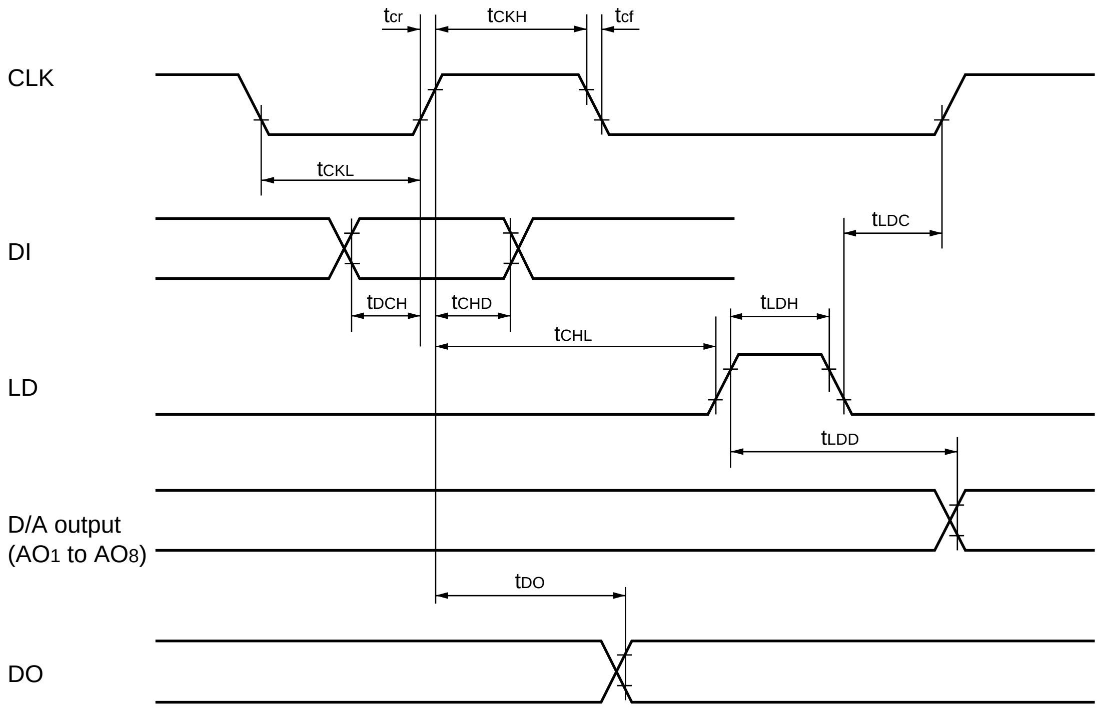
(V_{DD}, V_{CC} = + 5 V ± 10% ($V_{CC} \geq V_{DD}$) , GND, V_{SS} = 0 V, Ta = – 40 °C to + 85 °C)

Parameter	Symbol	Conditions	Value		Unit
			Min	Max	
"L" level clock pulse width	t_{CKL}	—	200	—	ns
"H" level clock pulse width	t_{CKH}	—	200	—	ns
Clock rising time Clock falling 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
"H" level load pulse width	t_{LDH}	—	100	—	ns
Data output delay time	t_{DO}	Refer to "Load condition (1) ".	70	350	ns
D/A output settling time	t_{LDD}	Refer to "Load condition (2) ".	—	100	µs

• Load condition

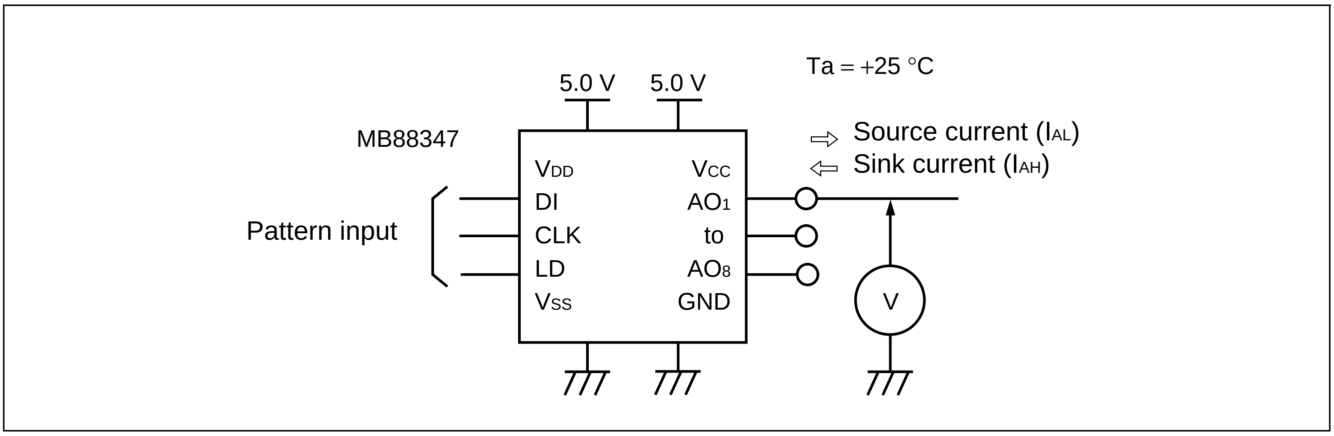


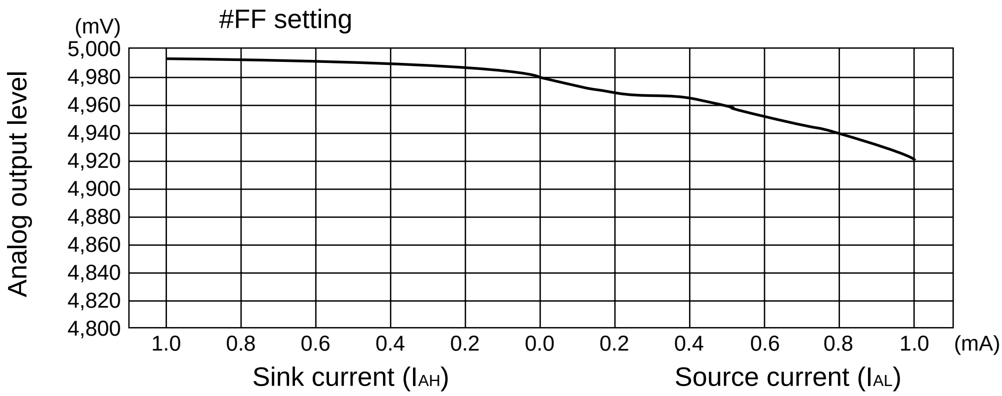
• Input/output timing

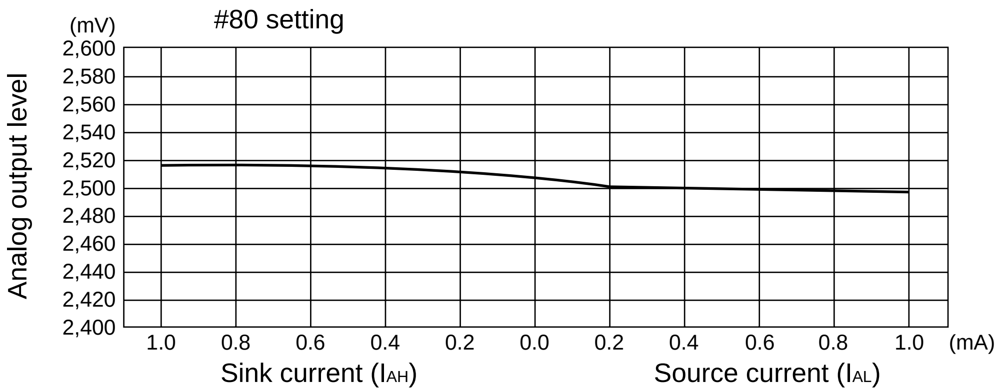


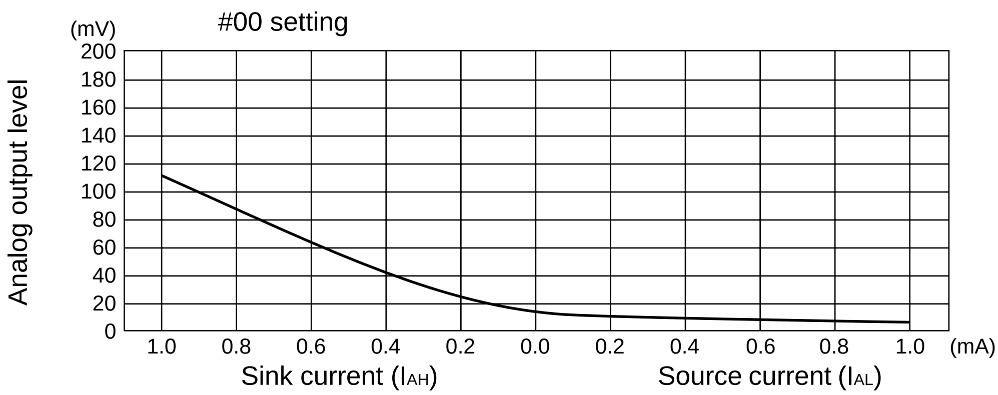
Note : The D/A output evaluation level is 90% and 10% of V_{CC}. The other evaluation level is 80% and 20% of V_{CC}.

■ EXAMPLE CHARACTERISTIC of V_{AO} - I_{AO}




#FF setting
(mV)
5,000
4,980
4,960
4,940
4,920
4,900
4,880
4,860
4,840
4,820
4,800
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 (IAH)
Source current (IAL)


#80 setting
(mV)
2,600
2,580
2,560
2,540
2,520
2,500
2,480
2,460
2,440
2,420
2,400
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 (IAH)
Source current (IAL)

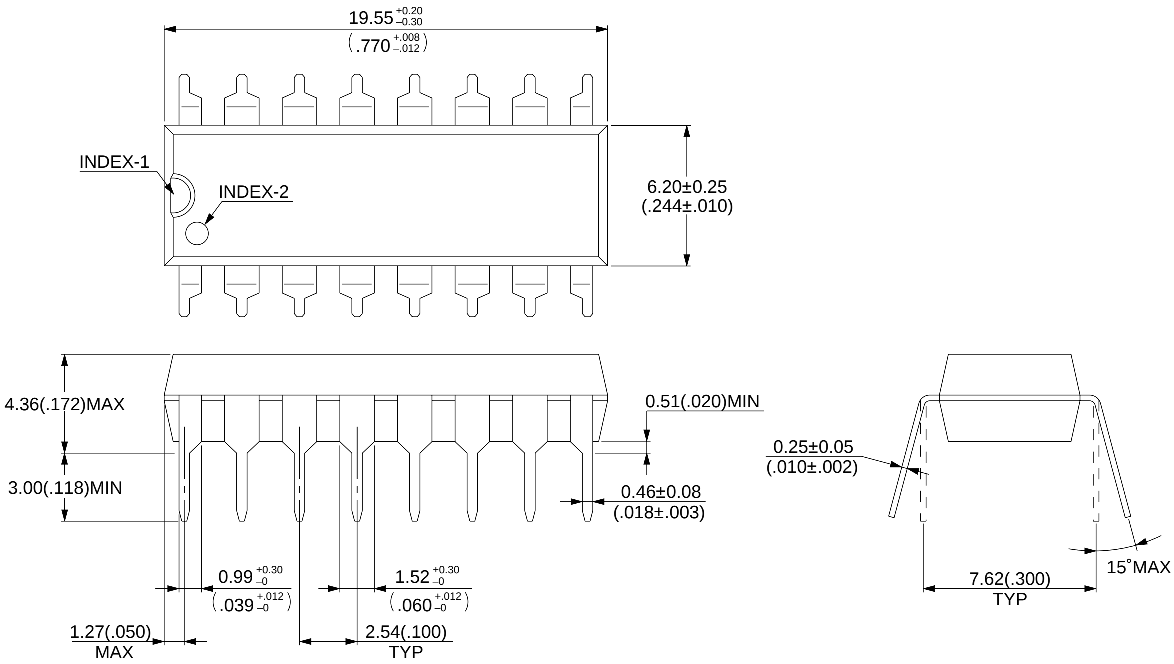

#00 setting
(mV)
200
180
160
140
120
100
80
60
40
20
0
Analog output level
1.0 0.8 0.6 0.4 0.2 0.0 0.2 0.4 0.6 0.8 1.0 (mA)
Sink current (IAH)
Source current (IAL)

■ ORDERING INFORMATION

Part No.	Package	Remarks
MB88347P	16-pin plastic DIP (DIP-16P-M04)	
MB88347PF	16-pin plastic SOP (FPT-16P-M06)	
MB88347PFV	16-pin plastic SSOP (FPT-16P-M05)	

■ PACKAGE DIMENSIONS

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

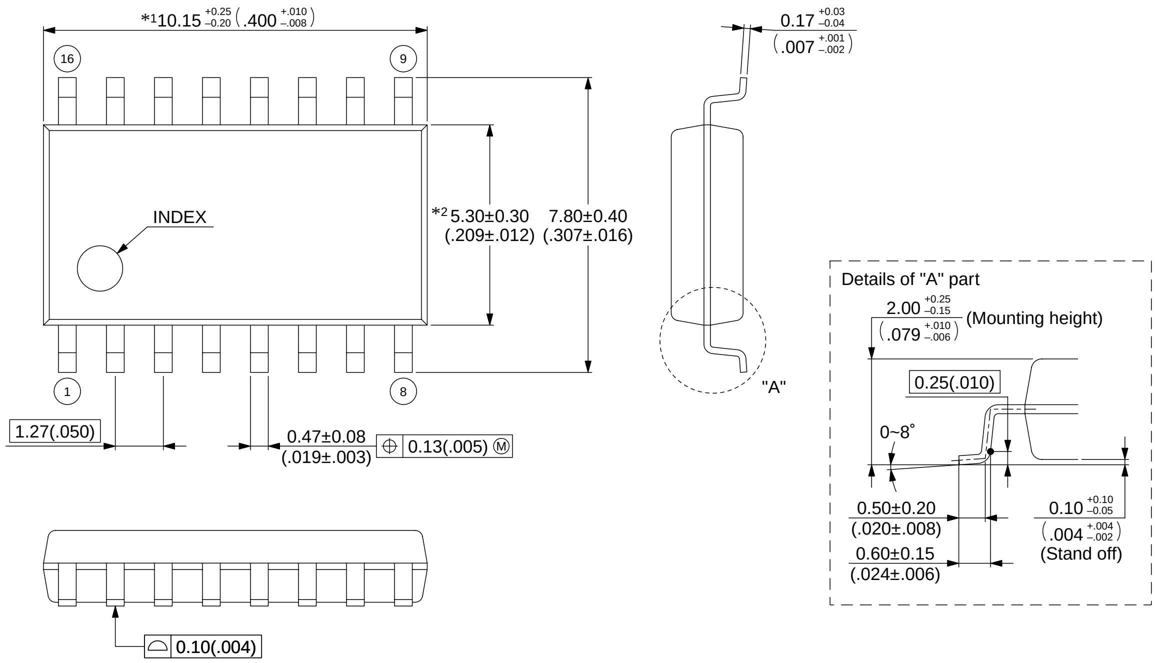


Dimensions in mm (inches).
Note : The values in parentheses are reference values.

(Continued)

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.



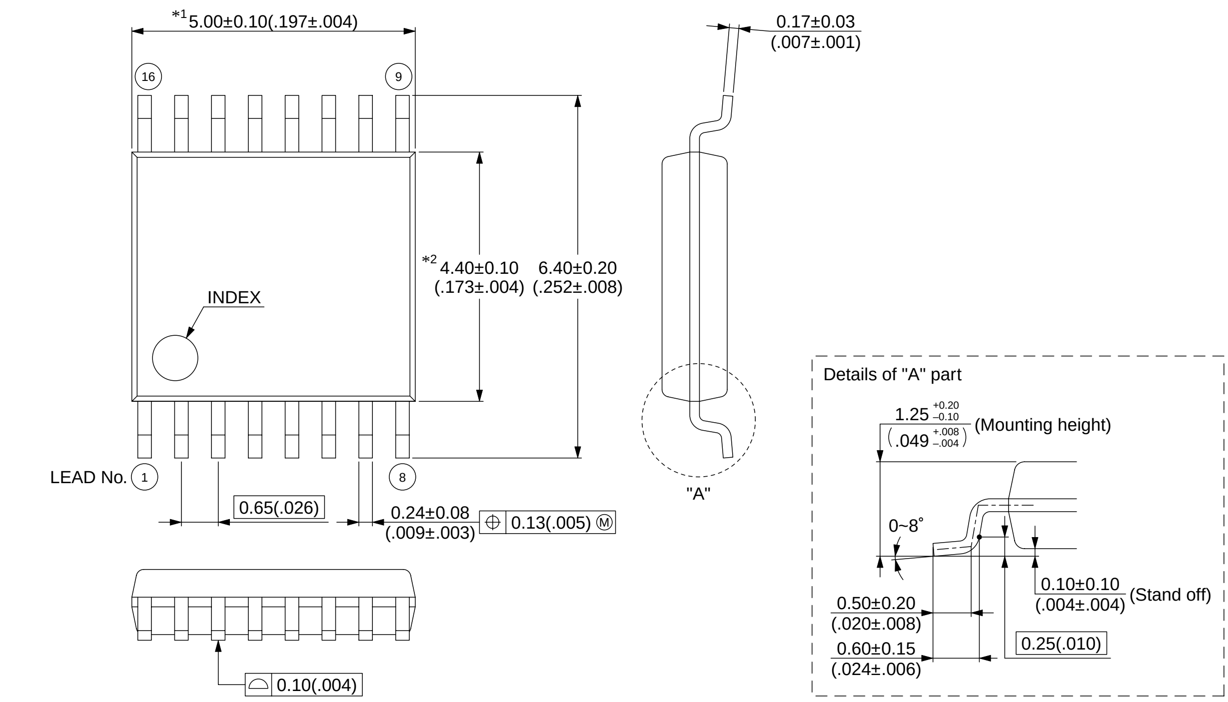
Dimensions in mm (inches).
Note: The values in parentheses are reference values.

(Continued)

(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.



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

MB88347

FUJITSU LIMITED

F0503