FUJITSU SEMICONDUCTOR
DATA SHEET

DS04-13512-2E

Linear IC converter

CMOS

D/A Converter for Digital Tuning

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

MB88347L

■ DESCRIPTION

The MB88347L incorporates eight 8-bit D/A converter modules. This device operates at low supply voltage in the performance guarantee range from 2.7 to 3.6 V. It also contains an output amplifier, allowing driving at large current.

Since the MB88347L inputs data in serial mode, it requires only three control lines for data input and two or more MB88347L units can be cascaded.

The MB88347L is function and pin compatible with the MB88347 (5-volt supply voltage model). The MB88347L can therefore easily replace the MB88347 in a system, thereby reducing the system's voltage requirement.

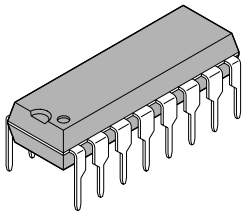
The MB88347L is the best replacement for electronic variable resistors or screwdriver control resistors.

■ FEATURES

- Ultra-low power consumption (0.5 mW/ch: typical)
- Low voltage operation (V_{CC} = 2.7 to 3.6 V)
- Ultra-compact space-saving package (SSOP-16)
- Contains 8-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 V 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
- CMOS process
- Package lineup includes DIP 16-pin, SOP 16-pin, SSOP 16-pin

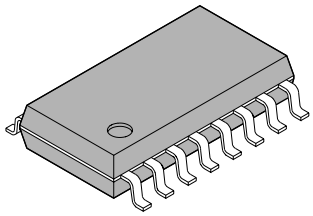
■ PACKAGES

16 pin, Plastic DIP



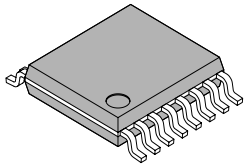
(DIP-16P-M04)

16 pin, Plastic SOP



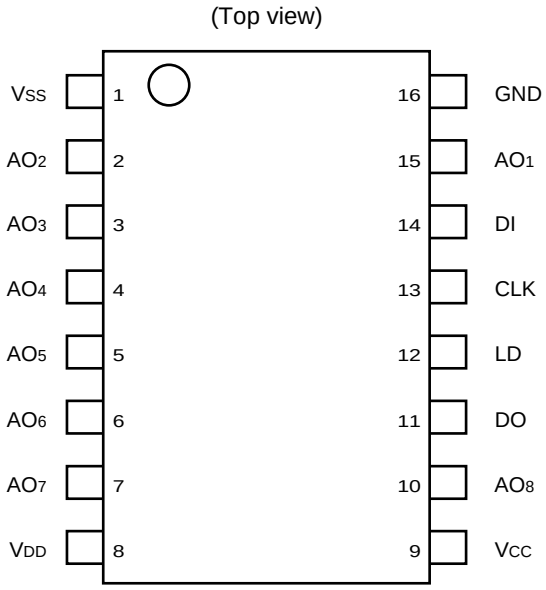
(FPT-16P-M06)

16 pin, Plastic SSOP



(FPT-16P-M05)

■ PIN ASSIGNMENT

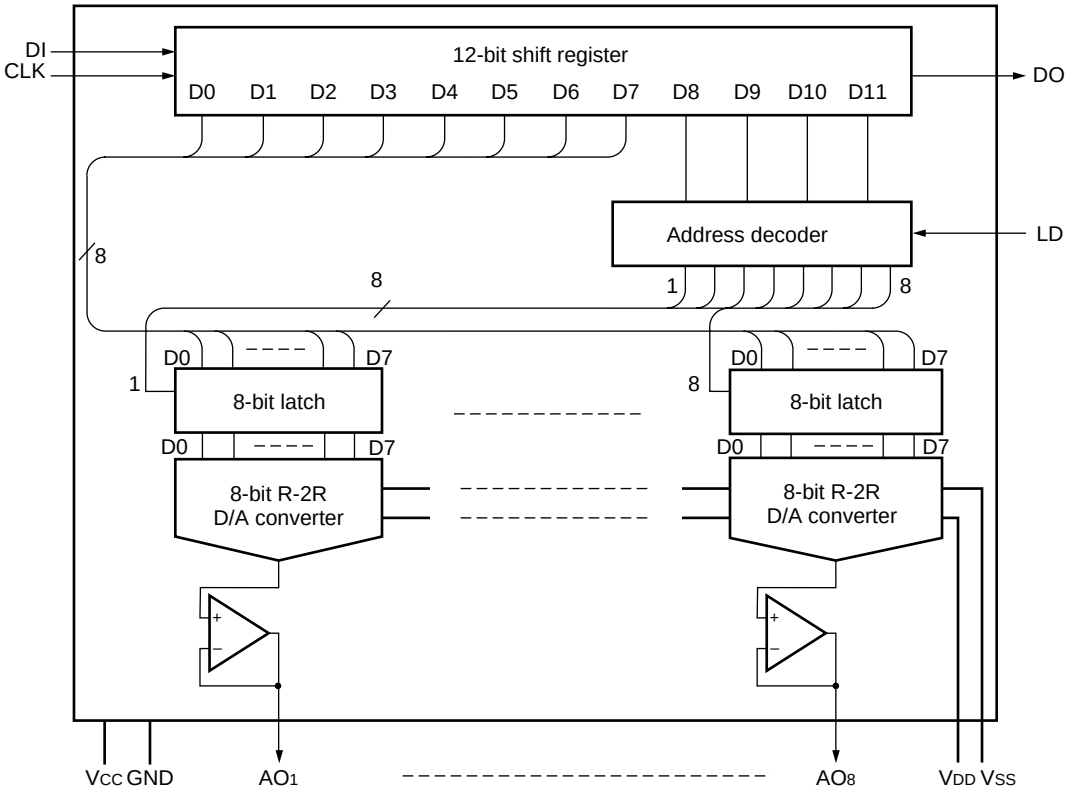


(DIP-16P-M04)
(FPT-16P-M06)
(FPT-16P-M05)

■ PIN DESCRIPTION

Pin No.	Pin name	I/O	Functions
14	DI	I	Serial data input pin. This pin inputs serial data with a data length of 12 bits. (Do not leave the pin floating.)
11	DO	O	This pin outputs the MSB data in the 12-bit shift register at the CLK falling edge.
13	CLK	I	Shift clock input pin. The input signal from the DI pin enters the 12-bit shift register at the rising edge of the shift clock pulse. (Do not leave this pin floating.)
12	LD	I	When the LD pin inputs the High-level signal, shift register value is loaded to the decoder and the D/A output register. (Do not leave this pin floating. When data is not transferred, fix the pin to the “Low” level.)
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	8-bit D/A output with op amp.
9	V_{CC}	—	MCU interface and OP amp power-supply pin.
16	GND	—	MCU interface and OP amp GND pin.
8	V_{DD}	—	D/A converter reference power (High) input pin.
1	V_{SS}	—	D/A converter reference power (Low) input pin.

■ BLOCK DIAGRAM

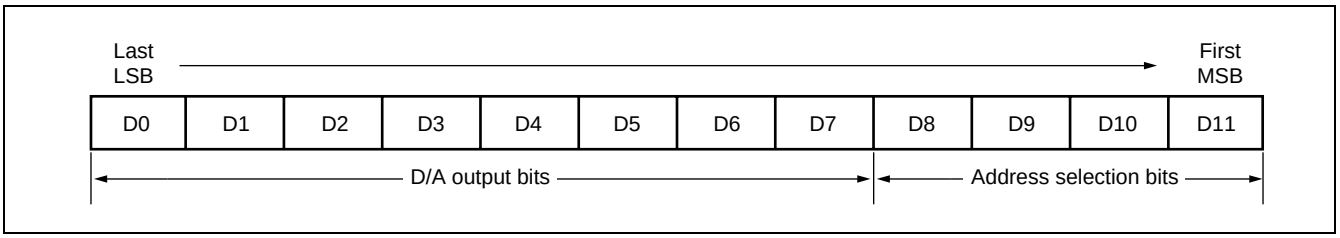


■ DATA CONFIGURATION

The MB88347L has a 12-bit shift register for chip control.

The 12-bit shift register must be used to set up data in the configuration shown below.

The data configuration has a total of 12 bits, for address selection and eight for D/A data output.



- **D/A converter control signals**

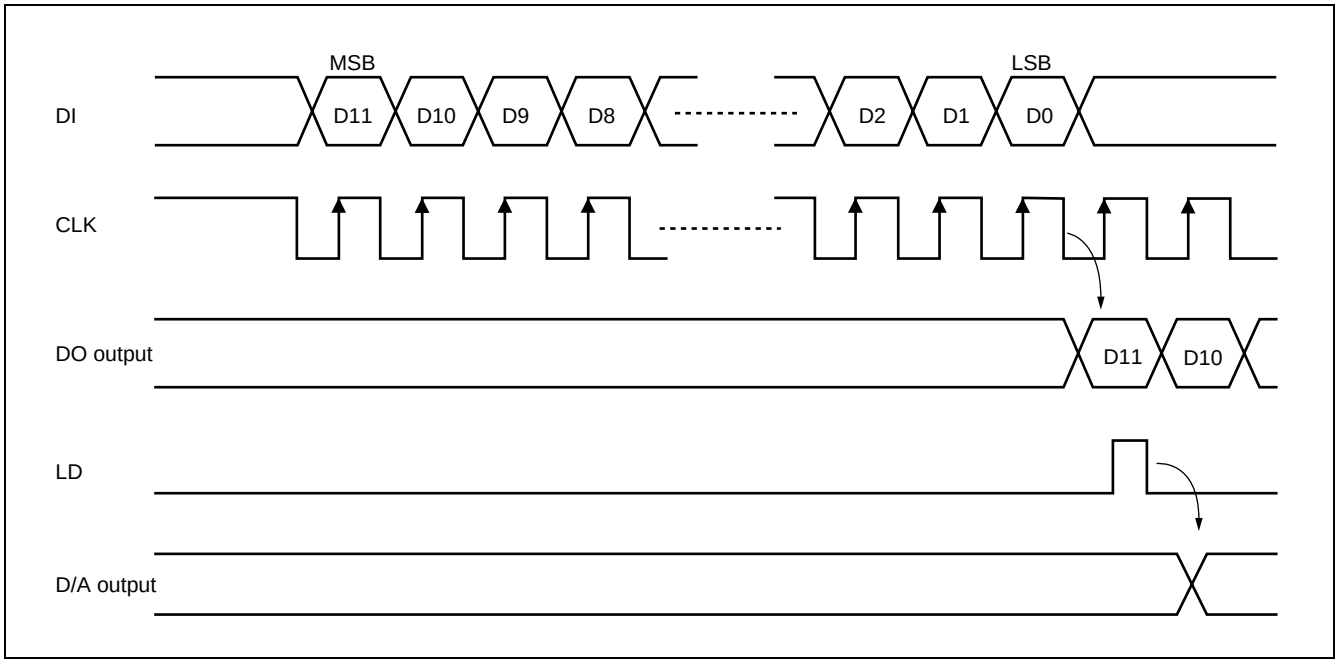
D0	D1	D2	D3	D4	D5	D6	D7	D/A data output
0	0	0	0	0	0	0	0	≅ V_{SS}
1	0	0	0	0	0	0	0	≅ $V_{LB} \times 1 + V_{SS}$
0	1	0	0	0	0	0	0	≅ $V_{LB} \times 2 + V_{SS}$
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
0	1	1	1	1	1	1	1	≅ $V_{LB} \times 254 + V_{SS}$
1	1	1	1	1	1	1	1	≅ $V_{LB} \times 255 + V_{SS}$

Note: $V_{LB} = (V_{DD} - V_{SS})/256$

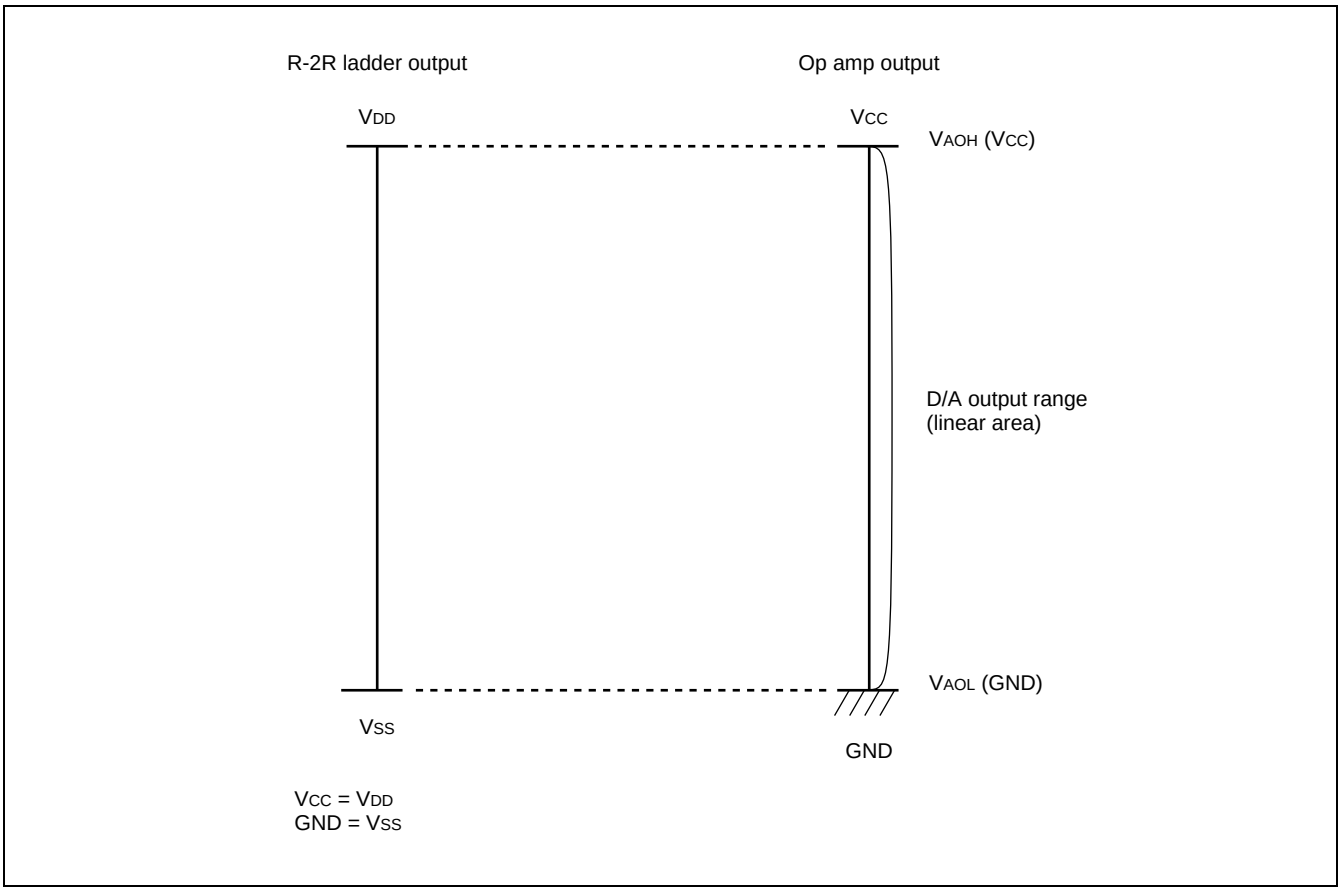
- **Address selection signals**

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	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

■ DATA SETTING TIMING CHART



■ ANALOG OUTPUT VOLTAGE RANGE



■ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Conditions	Rating		Unit
			Min.	Max.	
Supply voltage	V_{CC}	Based on GND Ta = +25°C	–0.3	5.0	V
	V_{DD}		–0.3*	5.0*	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	Conditions	Rating		Unit
			Min.	Max.	
Power supply voltage 1	V_{CC}	—	2.7	3.6	V
	GND	—	Typical: 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
Oscillation limit output capacity	C_{OL}	—	—	1.0	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 FUJITSU 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 name	Conditions	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}		Operation at CLK = 1 MHz (with no load)	—	0.8	2.0	mA
Input leak current	I_{ILK}	CLK DI LD	V_{IN} = 0 V 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

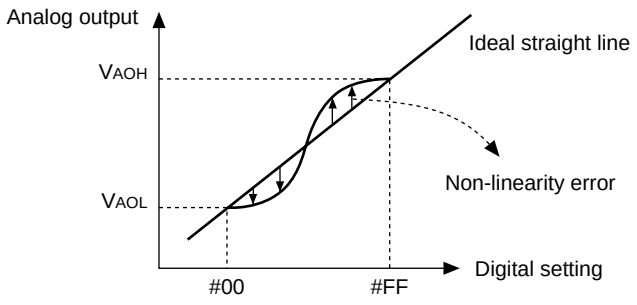
(2) Analog block (1)

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

Parameter	Symbol	Pin name	Conditions	Value			Unit
				Min.	Typ.	Max.	
Power consumption	I_{DD}	V_{DD}	No load	—	0.6	1.0	mA
Analog 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	—	bits
Monotonic increase	Rem		No load $V_{DD} \leq V_{CC} – 0.1$ V $V_{SS} \geq 0.1$ V	—	8	—	bits
Non-linearity error*1	LE			–1.5	—	1.5	LSB
Differential linearity error*2	D_{LE}			–1.0	—	1.0	LSB

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

*2: 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 section (2)

(Ta = –20°C to +85°C)

Parameter	Symbol	Pin name	Conditions	Values			Unit
				Min.	Typ.	Max.	
Output minimum voltage 1	V_{AOL1}	AO_1 to AO_8	$V_{DD} = V_{CC} = 3.0$ 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

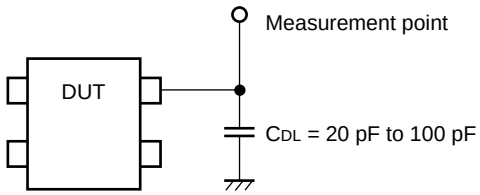
2. AC Characteristics

(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)

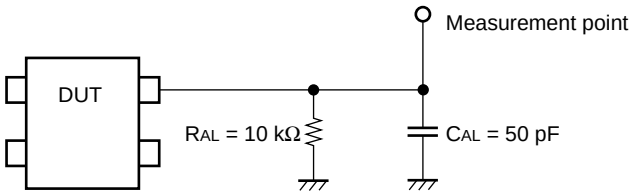
Parameter	Symbol	Conditions	Rating		Unit
			Min.	Max.	
Clock L level pulse width	t_{CKL}	—	200	—	ns
Clock H level pulse width	t_{CKH}	—	200	—	ns
Clock rise time Clock fall time	t_{Cr} t_{Cf}	—	—	200	ns
Data setup time	t_{DCH}	—	30	—	ns
Data hold time	t_{CHD}	—	60	—	ns
Load setup time	t_{CHL}	—	200	—	ns
Load hold time	t_{LDC}	—	100	—	ns
Load H level pulse width	t_{LDH}	—	100	—	ns
Data output delay time	t_{DO}	See “Load conditions (1).”	—	170	ns
D/A output settling time	t_{LDD}	See “Load conditions (2).”	—	200	µs

Load conditions

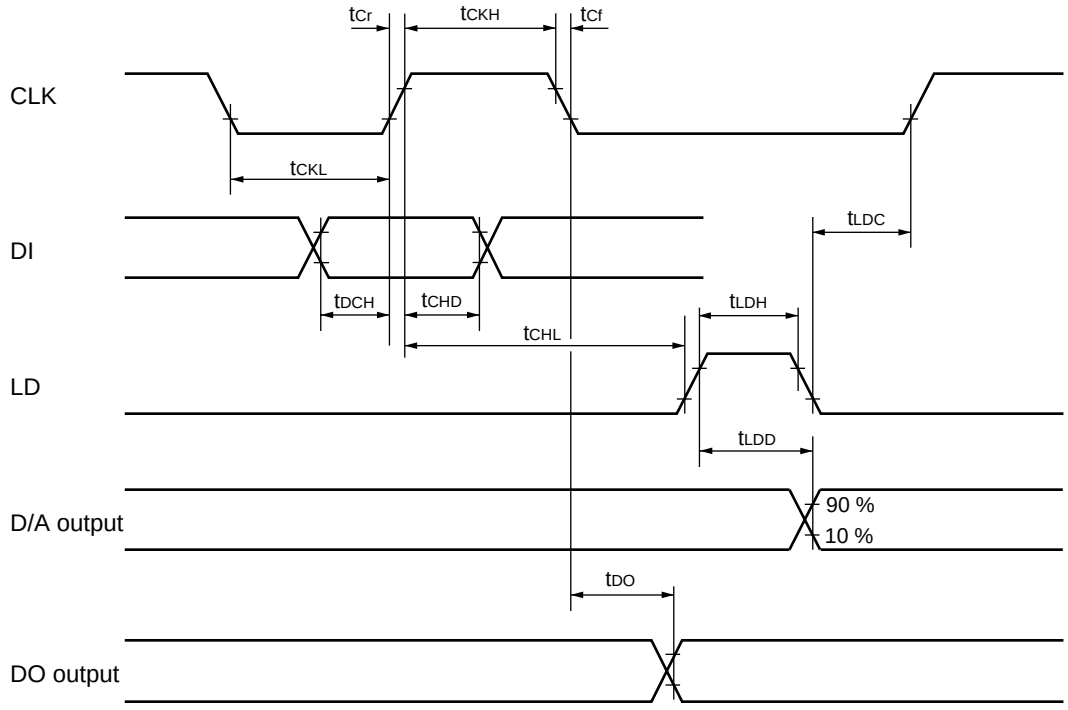
・Load conditoins (1)



・Load conditions (2)

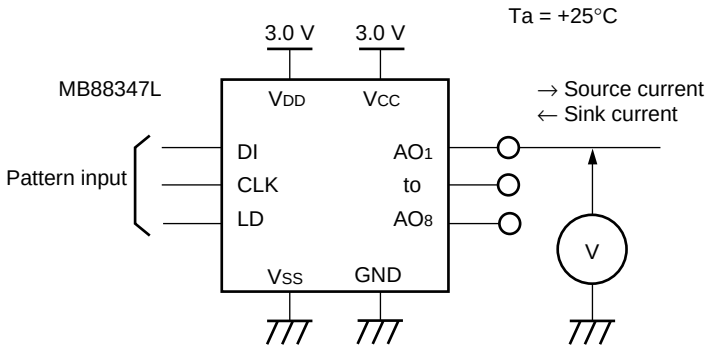


Input/output timing

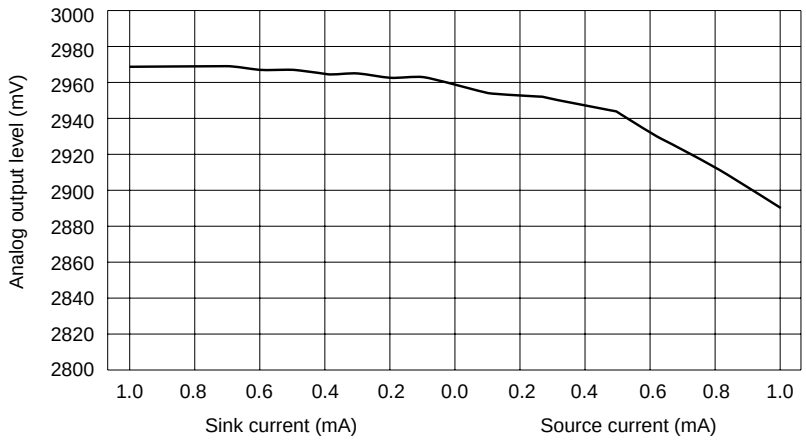


Note: Evaluation levels are 80% and 20% of V_{CC}.

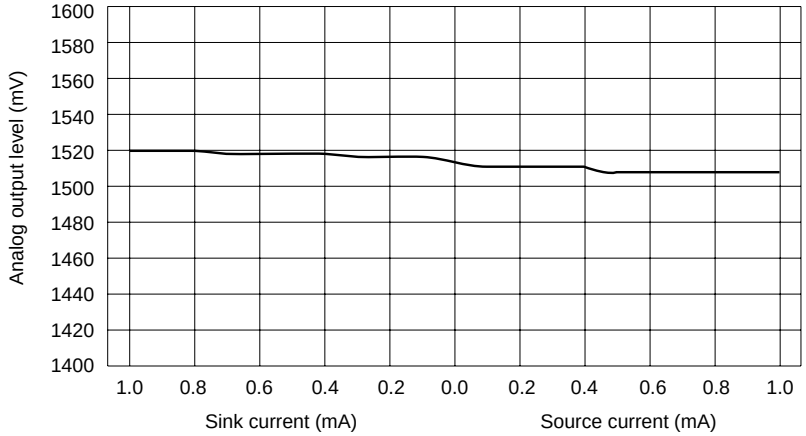
■ V_{AO} vs. I_{AO} CHARACTERISTICS: EXAMPLE



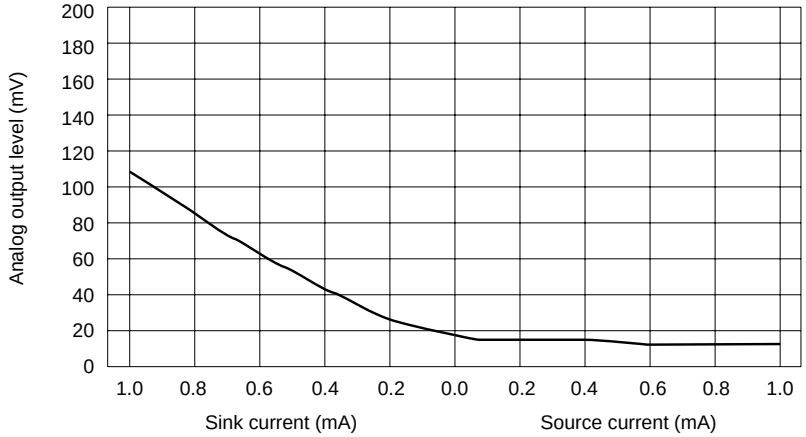
#FF setting



#80 setting



#00 setting



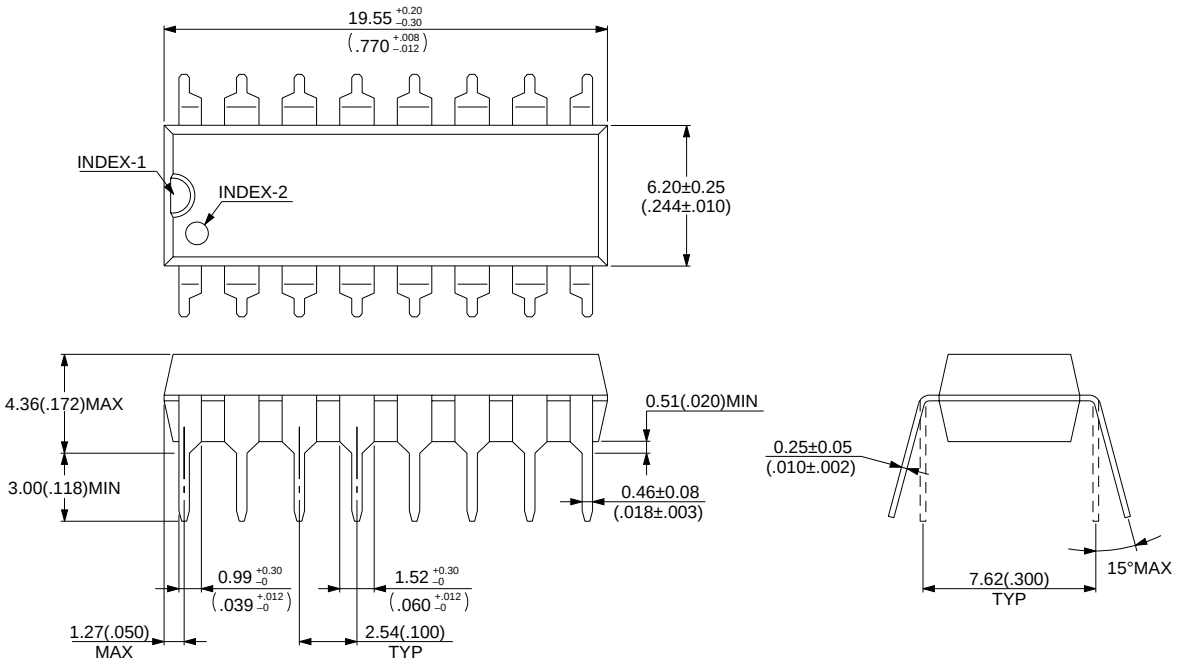
■ ORDERING INFORMATION

Part number	Package	Remarks
MB88347LP	16 pin, Plastic DIP (DIP-16P-M04)	
MB88347LPF	16 pin, Plastic SOP (FPT-16P-M06)	
MB88347LPFV	16 pin, Plastic SSOP (FPT-16P-M05)	

■ PACKAGE DIMENSIONS

16 pin, Plastic DIP

(DIP-16P-M04)

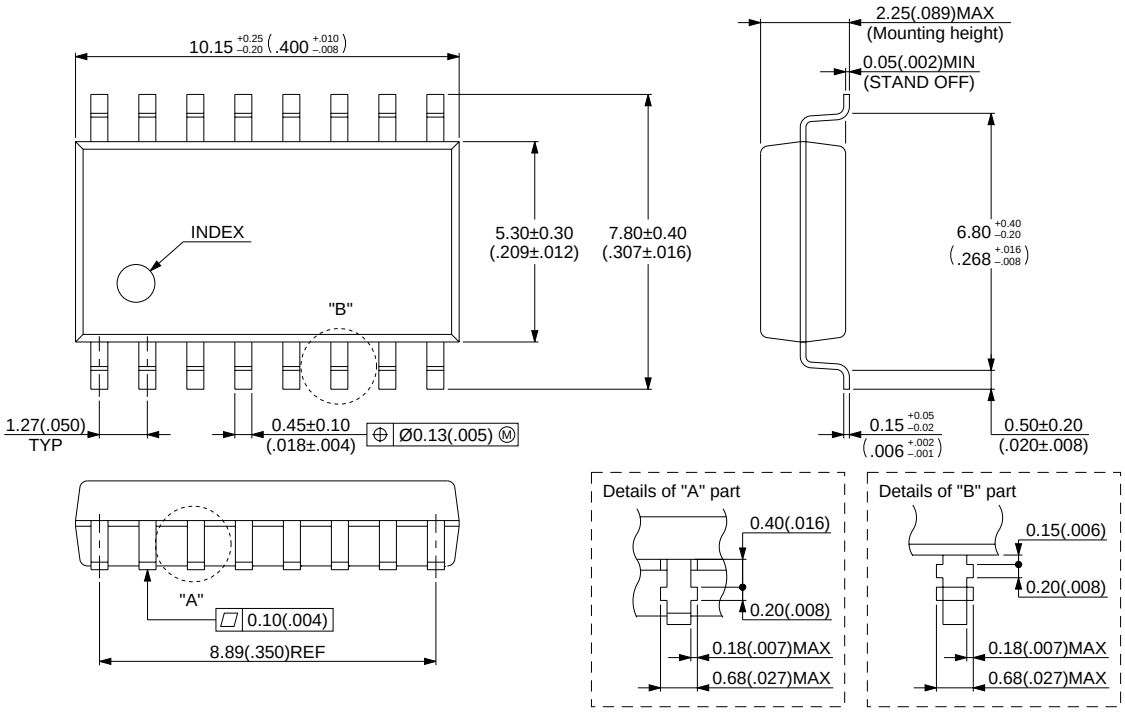


Dimensions in mm (inches).

(Continued)

16 pin, Plastic SOP

(FPT-16P-M06)



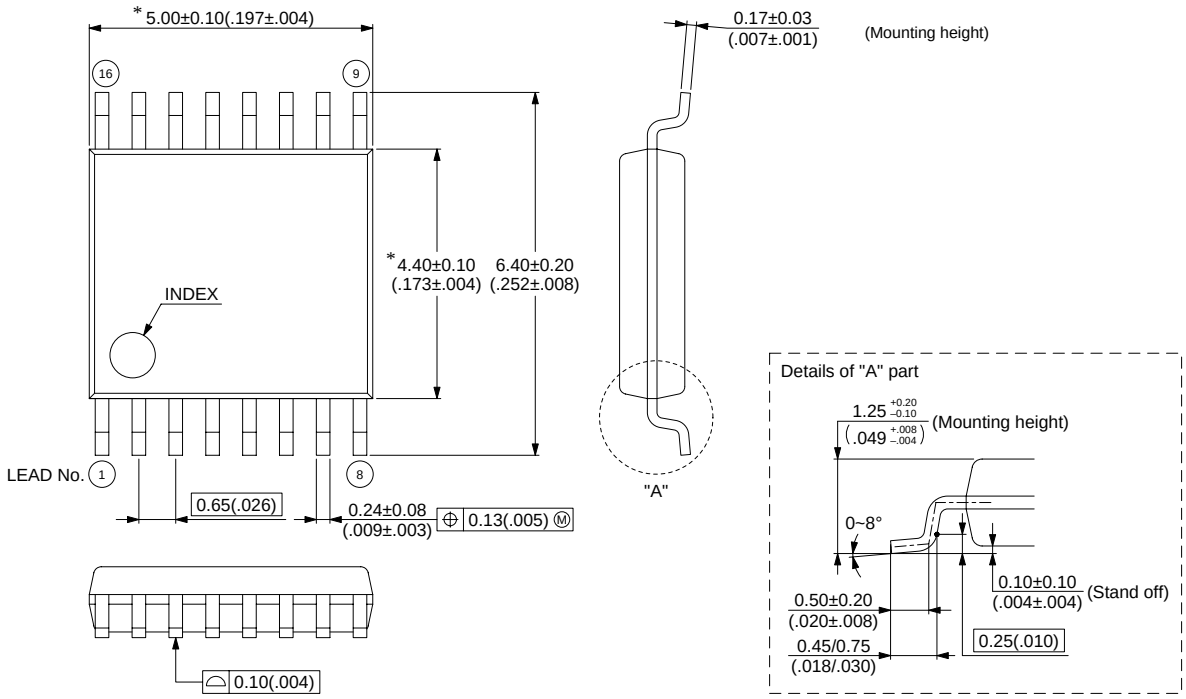
Dimensions in mm (inches).

(Continued)

16 pin, Plastic SSOP

(FPT-16P-M05)

Note 1) *: These dimensions do not include resin protrusion.
Note 2) Pins width and pins thickness include olating thickness.



Dimensions in mm (inches).

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