Linear IC   Converter

CMOS

D/A Converter for Digital Tuning
(24-channel, 8-bit, on-chip OP amp)

MB88345

■ DESCRIPTION

The MB88345 incorporates twenty-four 8-bit D/A converter modules.

It also contains an output amplifier, allowing driving at large current.

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

The MB88345 is suitable for applications such as electronic volume controls and replacement of semi-fixed resistors in tuning systems.

■ FEATURES

- Ultra-low power consumption (1.1 mW/ch : typical)
- Compact space-saving package (QFP-32)
- Contains 24-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 : 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
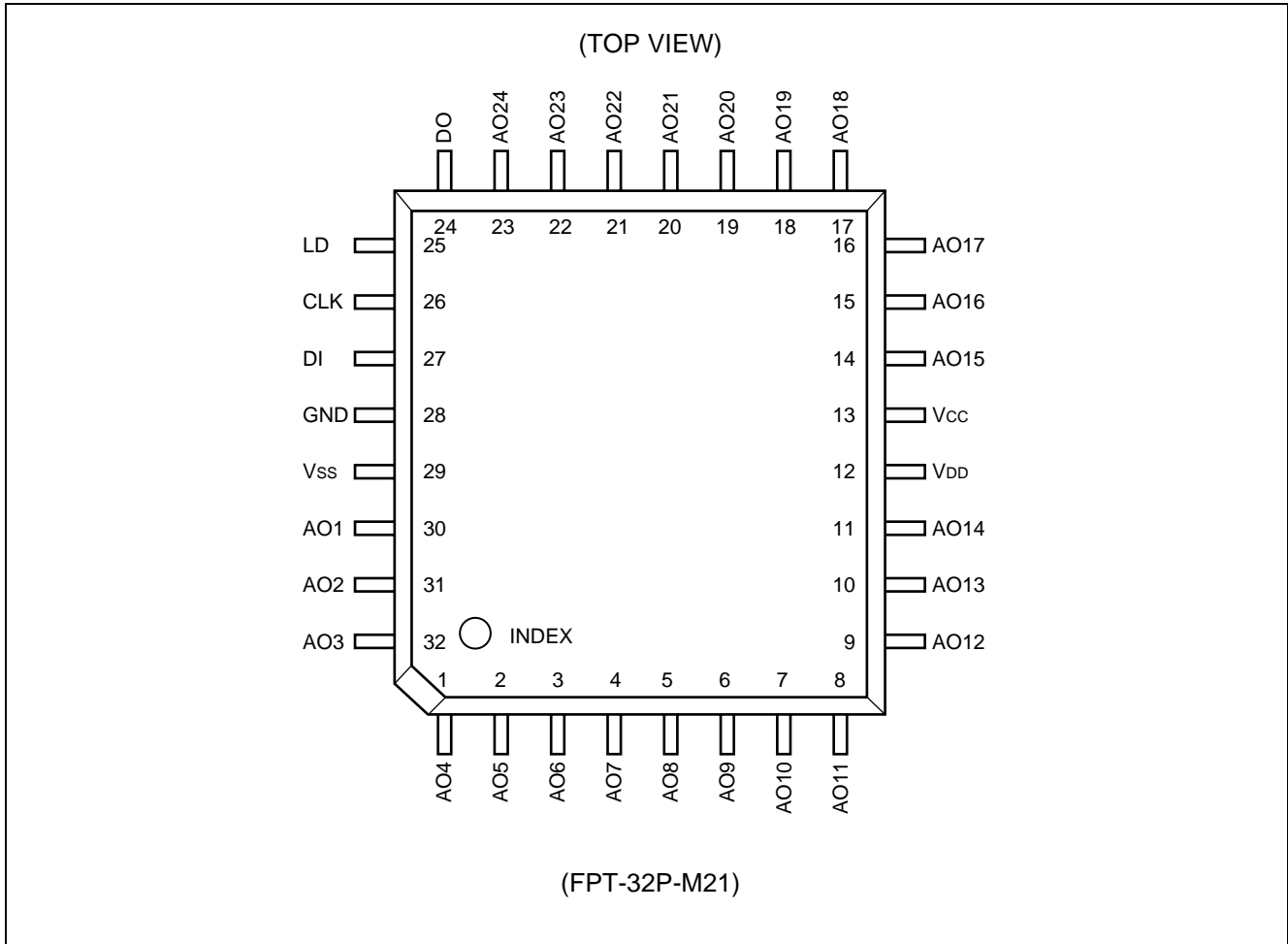- Serial data input : maximum operating speed 2.5 MHz
- CMOS process

■ PACKAGE

32-pin Plastic QFP

(FPT-32P-M21)

■ **PIN ASSIGNMENT**

(TOP VIEW)
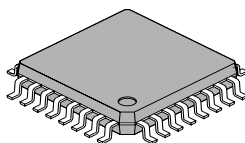
(FPT-32P-M21)

■ **PIN DESCRIPTION**

Pin No.	Pin name	I/O	Description
27	DI*	I	Serial data input pin. This pin inputs serial data with a data length of 14 bits.
24	DO	O	This pin outputs the MSB data in the 14-bit shift register.
26	CLK*	I	Shift clock input pin. The input signal from the DI pin enters the 14-bit shift register at the rising edge of the shift clock pulse.
25	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.
30 to 32 1 to 11 14 to 23	AO1 to AO3 AO4 to AO14 AO15 to AO24	O	8-bit D/A output with OP-amp.
13	VCC	—	MCU interface and OP-amp power-supply pin
28	GND	—	MCU interface and OP-amp GND pin
12	VDD	—	D/A converter power-supply pin
29	VSS	—	D/A converter GND pin

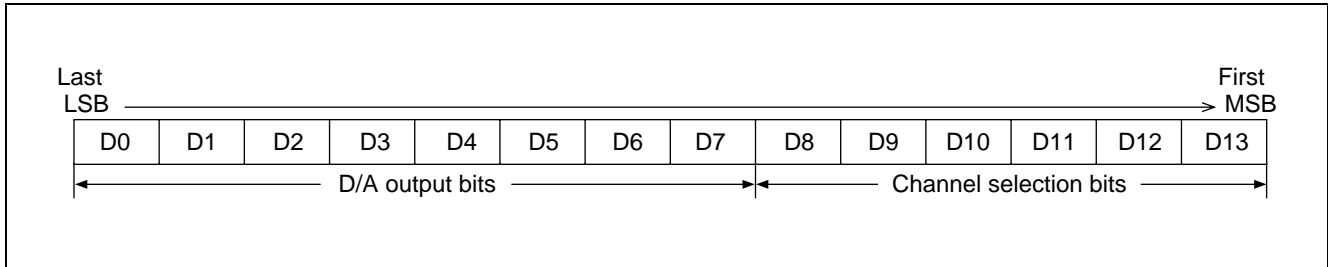* : DI, CLK, LD pins should be fixed with "Low"level while no data are transferred.

■ BLOCK DIAGRAM
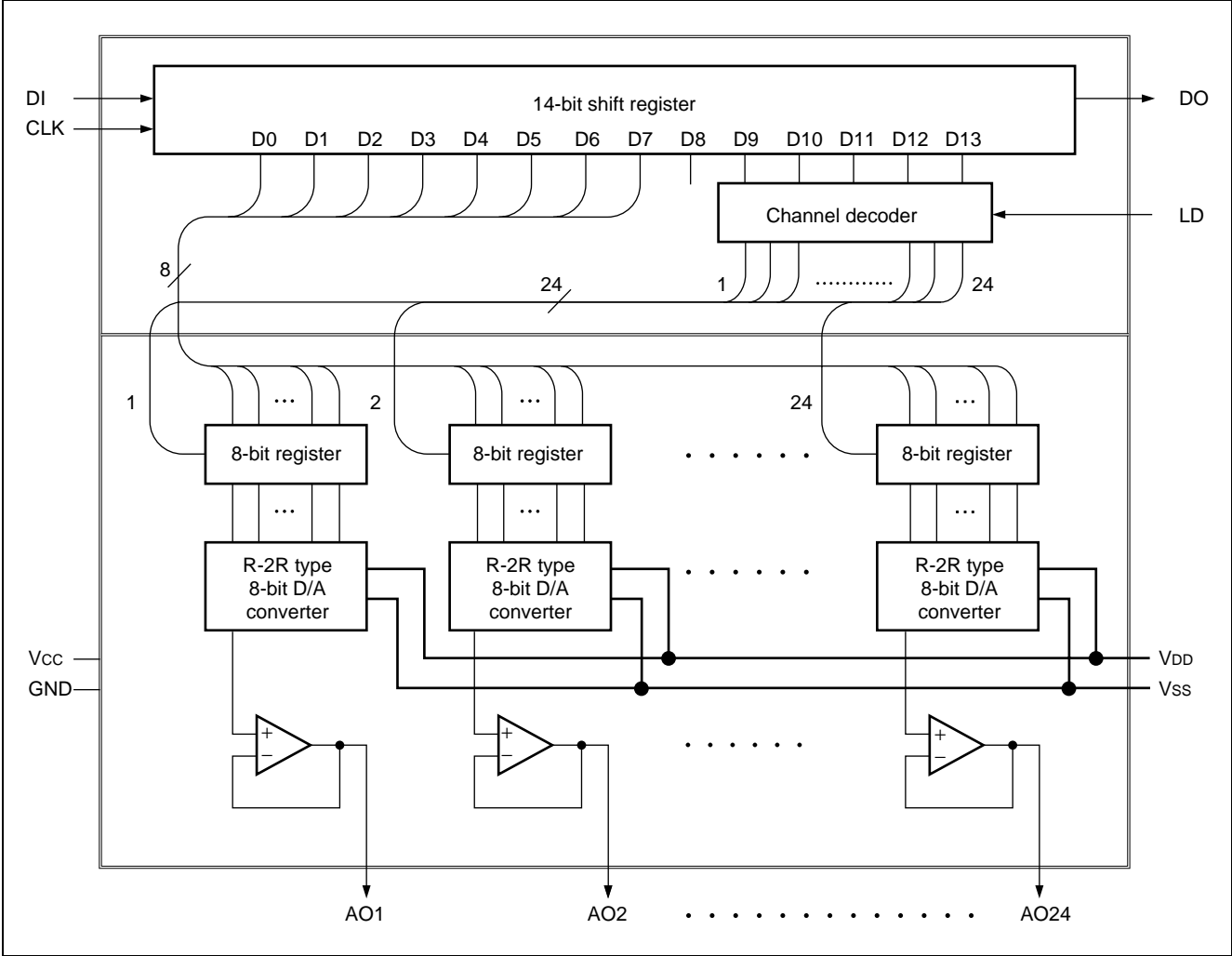
■ DATA CONFIGURATION

The MB88345 has a 14-bit shift register for chip control.

The 14-bit shift register must be used to set up data in the configuration shown below.

Note : The data configuration has a total of 14 bits, six for channel selection and eight for D/A data output.

Last LSB													First MSB
D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13
← D/A output bits →								← Channel selection bits →					

• D/A converter control signals

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

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

• Channel selection signals

Input data signal						Channel selection
D8	D9	D10	D11	D12	D13	
×	0	0	0	0	0	Deselected
×	0	0	0	0	1	AO1 Selection
×	0	0	0	1	0	AO2 Selection
≀	≀	≀	≀	≀	≀	≀
×	1	0	1	1	1	AO23 Selection
×	1	1	0	0	0	AO24 Selection
×	1	1	0	0	1	
×	1	1	0	1	0	
≀	≀	≀	≀	≀	≀	Deselected
×	1	1	1	1	0	
×	1	1	1	1	1	

× : Don't Care

■ TIMING CHART
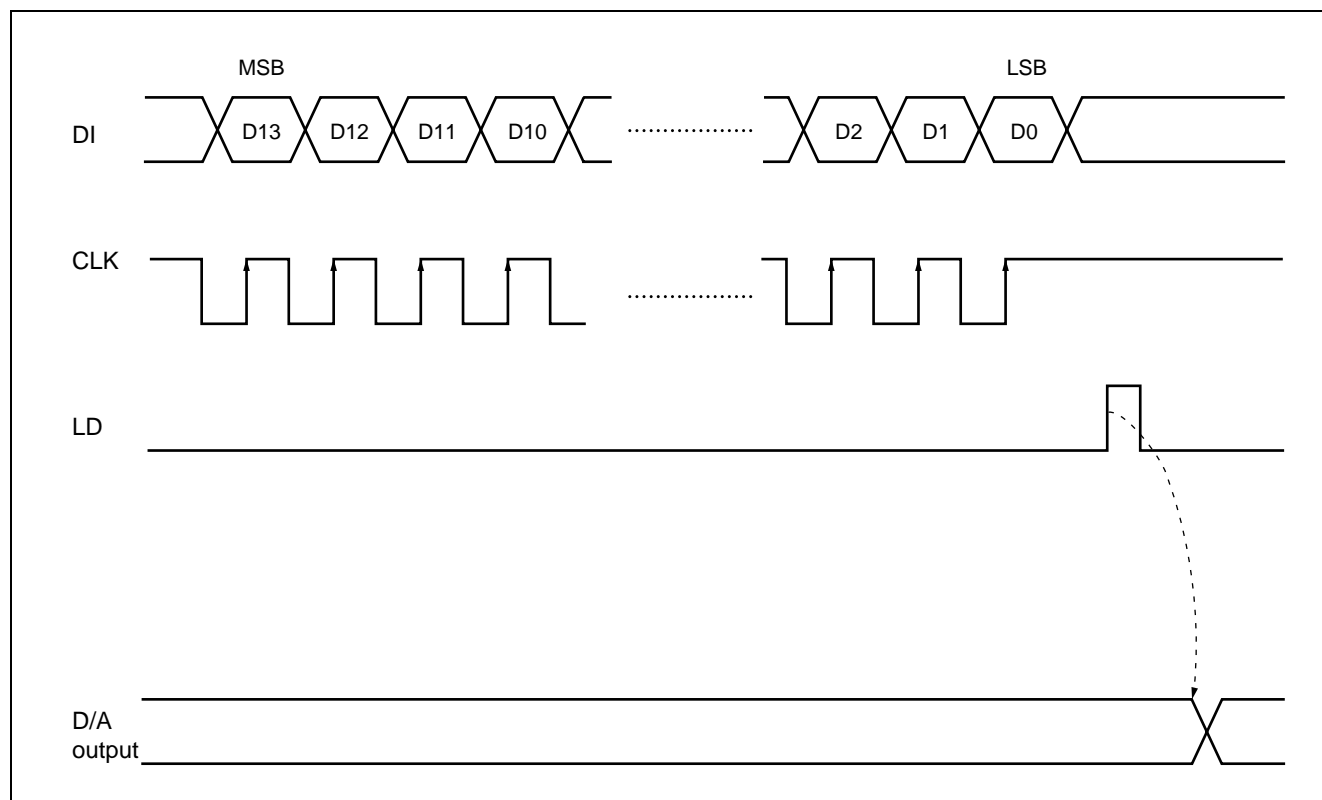
■ ANALOG OUTPUT VOLTAGE RANGE

MB88345
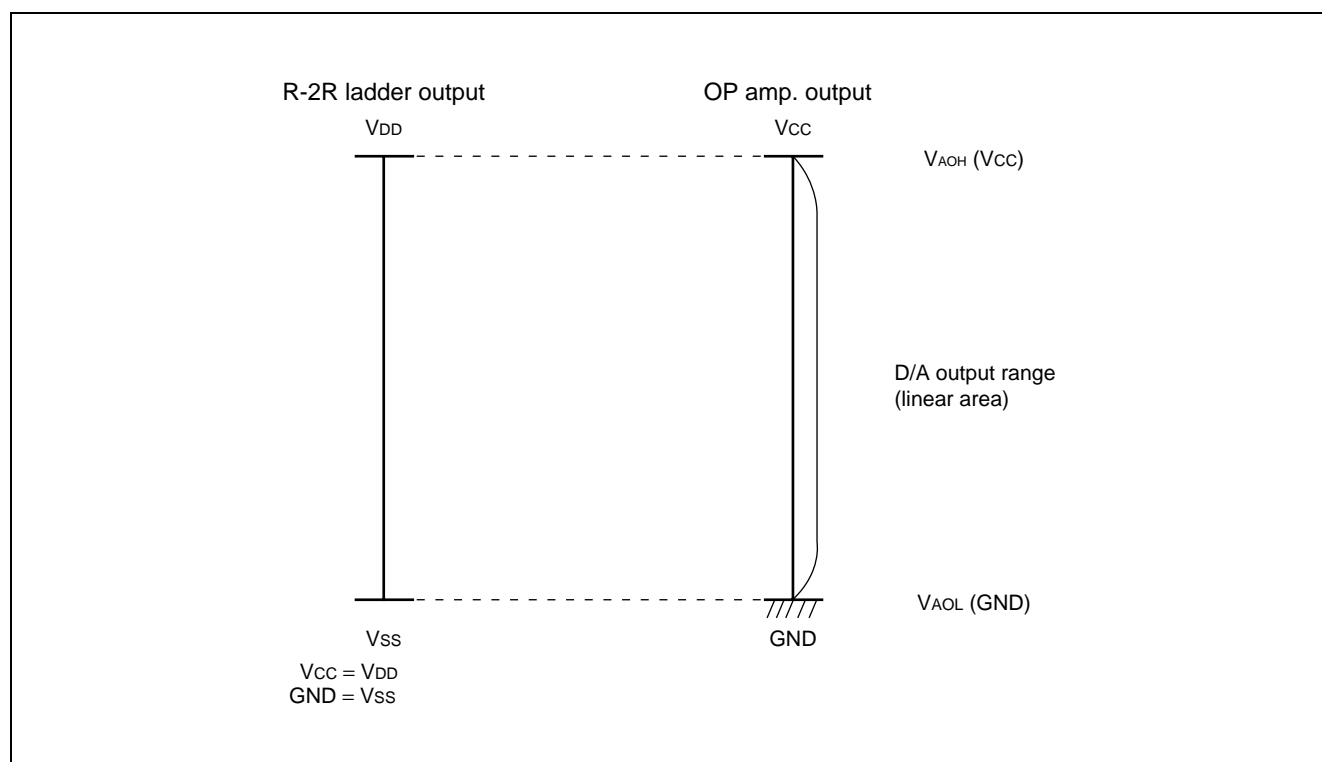
■ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Conditions	Rating		Unit
			Min.	Max.	
Power supply voltage	V_{CC}	Based on GND Ta = +25 °C	−0.3	+7.0	V
	V_{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	—	−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	Value	Unit
Power supply voltage 1	V_{CC}	—	5 V ± 10 %	V
	GND		0	V
Power supply voltage 2	V_{DD}	$V_{DD} - V_{SS} \geq 2.0$ V	2.0 to V_{CC}	V
	V_{SS}		GND to V_{CC} − 2.0	V
Analog output source current	I_{AL}	—	max. 1.0	mA
Analog output sink current	I_{AH}		max. 1.0	mA
Oscillation limit output capacity	C_{OL}		max. 1.0	μF
Digital data value range	—		#00 to #FF	—
Operating temperature	Ta		−20 to +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, $V_{SS} = 0$ V, Ta $= -20$ °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}		Operation at CLK = 1 MHz (No load)	—	2.4	5.4	mA
Input leak 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

(2) Analog block (1)

$(V_{DD}, V_{CC} = +5 \text{ V} \pm 10\% \, (V_{CC} \geq V_{DD})$, 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	—	3.0	4.5	mA
Analog Voltage	V_{DD}		V_{DD} − V_{SS} ≥ 2.0 V	2.0	—	V_{CC}	V
	V_{SS}	V_{SS}		GND	—	V_{CC} − 2.0	V
Resolution	Res	AO1 to AO24	—	—	8	—	bit
Monotonic increase	Rem		No load $V_{DD} \leq V_{CC}$ − 0.1V $V_{SS} \geq 0.1$ V	—	8	—	bit
Non-linearity error	LE			−1.5	—	1.5	LSB
Differential linearity error	D_{LE}			−1.0	—	1.0	LSB

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

Differential linearity error : Deviation (error) in amplification with respect to theoretical increase in amplification per 1-bit increase in digital value.
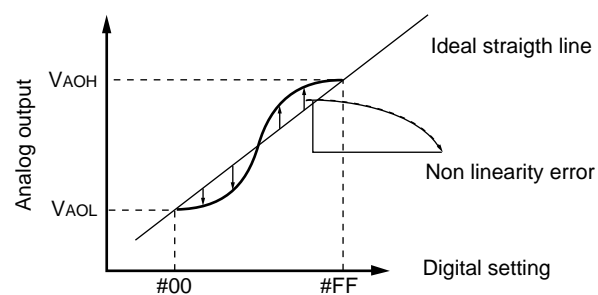
Note : The value of V_{AOH} and V_{DD}, and the value of V_{AOL} and V_{SS} are not necessarily equivalent.

(3) Analog block (2)

$(V_{DD}, V_{CC} = +5\ V \pm 10\%\ (V_{CC} \geq V_{DD})$, GND, $V_{SS} = 0\ V$, Ta $= -20\ ^\circ C$ to $+85\ ^\circ C)$

Parameter	Symbol	Pin name	Conditions	Value			Unit
				Min.	Typ.	Max.	
Output minimum voltage 1	V_{AOL1}		$V_{DD} = V_{CC}$ $V_{SS} = GND = 0\ V$ $I_{AL} = 0\ \mu A$ Digital data = #00	V_{SS}	—	$V_{SS} + 0.1$	V
Output minimum voltage 2	V_{AOL2}		$V_{DD} = V_{CC} = 5.0\ V$ $V_{SS} = GND = 0\ V$ $I_{AL} = 500\ \mu A$ Digital data = #00	$V_{SS} - 0.2$	V_{SS}	$V_{SS} + 0.2$	V
Output minimum voltage 3	V_{AOL3}		$V_{DD} = V_{CC} = 5.0\ V$ $V_{SS} = GND = 0\ V$ $I_{AH} = 500\ \mu A$ Digital data = #00	V_{SS}	—	$V_{SS} + 0.2$	V
Output minimum voltage 4	V_{AOL4}		$V_{DD} = V_{CC} = 5.0\ V$ $V_{SS} = GND = 0\ V$ $I_{AL} = 1.0\ mA$ Digital data = #00	$V_{SS} - 0.3$	V_{SS}	$V_{SS} + 0.3$	V
Output minimum voltage 5	V_{AOL5}	AO1 to AO24	$V_{DD} = V_{CC} = 5.0\ V$ $V_{SS} = GND = 0\ V$ $I_{AH} = 1.0\ mA$ Digital data = #00	V_{SS}	—	$V_{SS} + 0.3$	V
Output maximum voltage 1	V_{AOH1}		$V_{DD} = V_{CC}$ $V_{SS} = GND = 0\ V$ $I_{AL} = 0\ \mu A$ Digital data = #FF	$V_{DD} - 0.1$	—	V_{DD}	V
Output maximum voltage 2	V_{AOH2}		$V_{DD} = V_{CC} = 5.0\ V$ $V_{SS} = GND = 0\ V$ $I_{AL} = 500\ \mu A$ Digital data = #FF	$V_{DD} - 0.2$	—	V_{DD}	V
Output maximum voltage 3	V_{AOH3}		$V_{DD} = V_{CC} = 5.0\ V$ $V_{SS} = GND = 0\ V$ $I_{AH} = 500\ \mu A$ Digital data = #FF	$V_{DD} - 0.2$	V_{DD}	$V_{DD} + 0.2$	V
Output maximum voltage 4	V_{AOH4}		$V_{DD} = V_{CC} = 5.0\ V$ $V_{SS} = GND = 0\ V$ $I_{AL} = 1.0\ mA$ Digital data = #FF	$V_{DD} - 0.3$	—	V_{DD}	V
Output maximum voltage 5	V_{AOH5}		$V_{DD} = V_{CC} = 5.0\ V$ $V_{SS} = GND = 0\ V$ $I_{AH} = 1.0\ mA$ Digital data = #FF	$V_{DD} - 0.3$	V_{DD}	$V_{DD} + 0.3$	V

2. AC Characteristics

$(V_{DD}, V_{CC} = +5 \text{ V} \pm 10\% (V_{CC} \geq V_{DD}) , \text{GND}, V_{SS} = 0 \text{ V}, T_a = -20 \text{ °C to } +85 \text{ °C})$

Parameter	Symbol	Conditions	Value		Unit
			Min.	Max.	
"L" level clock pulse width	t_{CKL}	—	200	—	ns
"H" level clock pulse width	t_{CKH}		200	—	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
"H" level load pulse width	t_{LDH}		100	—	ns
Data output delay time	t_{DO}	See "Load conditions (1) "	—	150	ns
D/A output setting time	t_{LDD}	See "Load conditions (2) "	—	100	μs

• Load conditions

(1) Measurement point C_L = 20 pF to 100 pF

(2) Measurement point R_{AL} = 10 KΩ C_{AL} = 50 pF
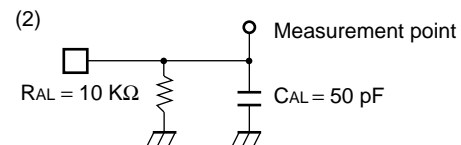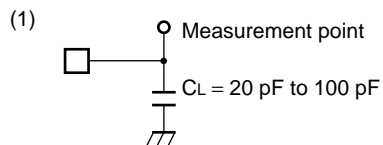
MB88345

• Input/output timing
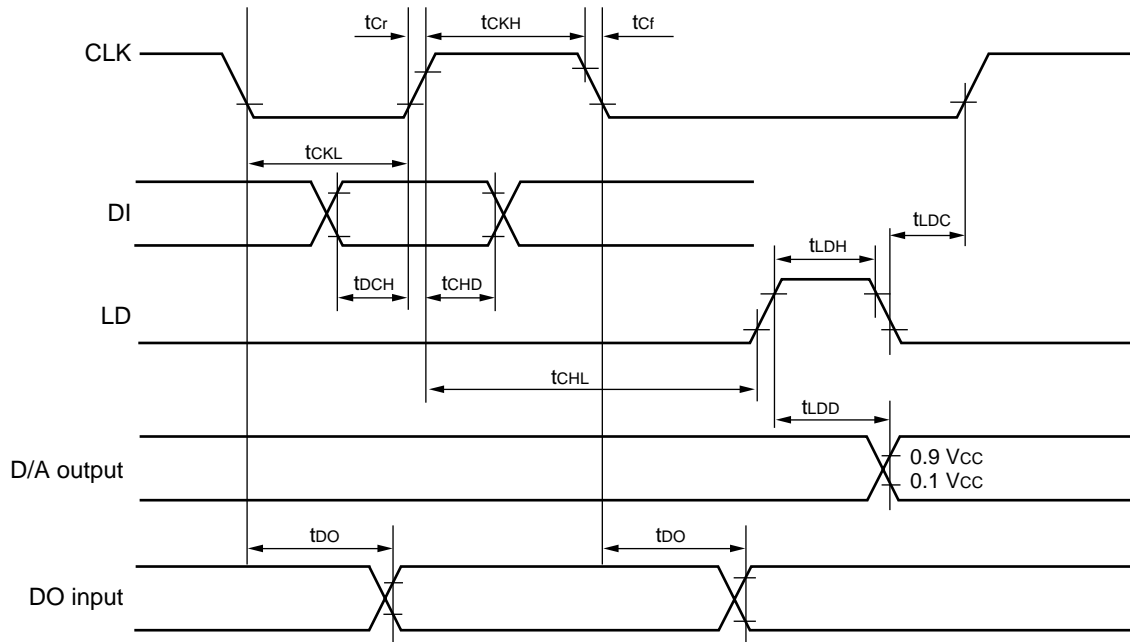
Note : Digital input decision level : 50% and 20% of Vcc.
      Digital output decision level : 80% and 20% of Vcc.
      Analog output decision level : 90% and 10% of Vcc.

■ V~AO~ vs. I~AO~ CHARACTERISTICS EXAMPLE
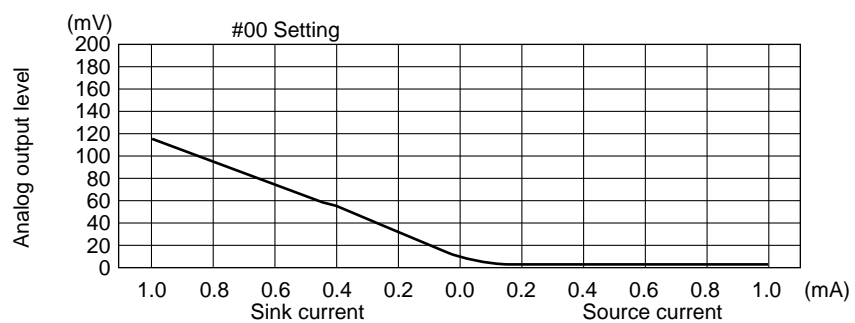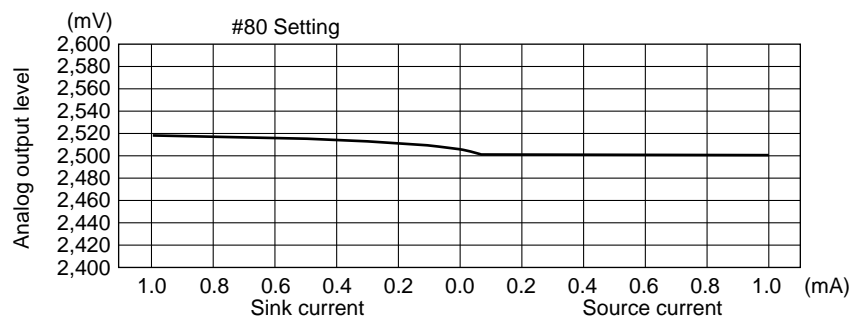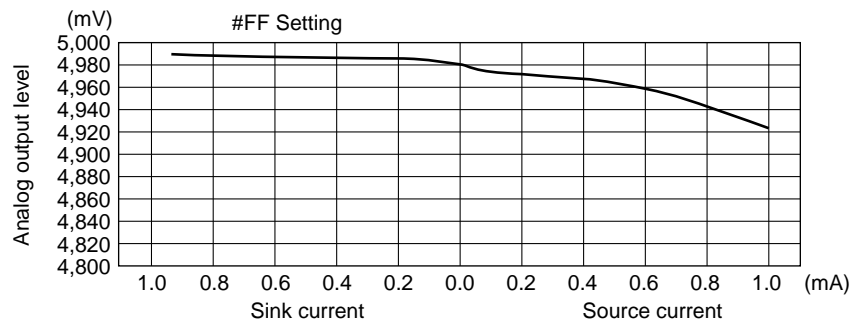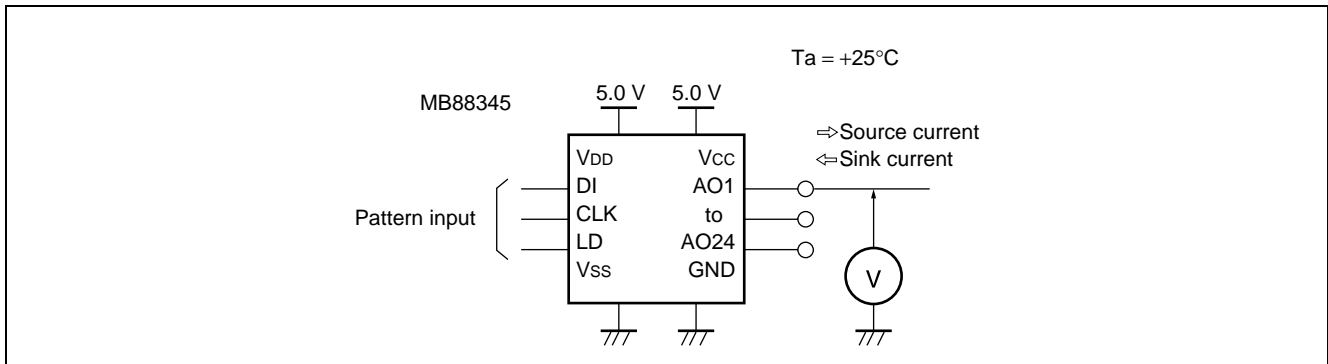
MB88345

■ ORDERING INFORMATION

Part number	Package	Remarks
MB88345PF	32 pin Plastic QFP (FPT-32P-M21)	

■ PACKAGE DIMENSION

32-pin, Plastic QFP
(FPT-32P-M21)

9.00±0.20(.354±.008)SQ

7.00±0.10(.276±.004)SQ

1 PIN INDEX

0.80(.0315)TYP

0.30±0.10
(.012±.004)

⊕ | 0.16(.006) Ⓜ

$1.50\,^{+0.20}_{-0.10}$
$\left(.059\,^{+.008}_{-.004}\right)$

5.60
(.220)
REF

8.00
(.315)
NOM

"A"

$0.127\,^{+0.05}_{-0.02}$
$\left(.005\,^{+.002}_{-.001}\right)$

▱ | 0.10(.004)

Details of "A" part

0.10±0.10
(.004±.004)

0.50±0.20
(.020±.008)

0 ～ 10°
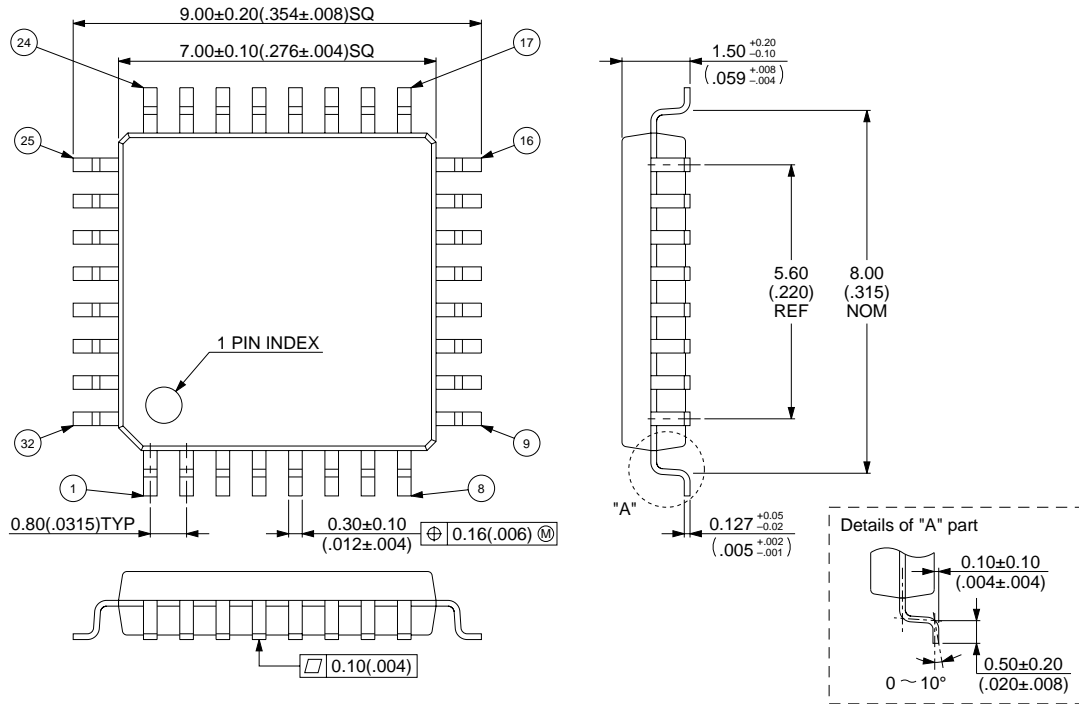
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Dimensions in mm (inches)

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MEMO

MEMO

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