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FUJITSU

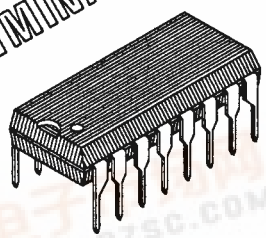
DATA SHEET

MB88353
R-2R Type 12-Bit D/A Converter

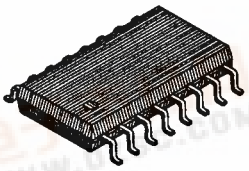
The Fujitsu MB88353 is an R-2R type 12-bit resolution digital-to-analog converter (DAC). It is designed to interface with a wide range of general 4-bit and 8-bit microcontrollers including Fujitsu's MB88200 family, MB8850 family, and MB88500 family of 4-bit single-chip microcontrollers.

The MB88353 has a 12-bit x 4-channel D/A converter. Digital data are input serially by individual channel units. The loaded digital data are converted into analog DC voltages by the D/A converter in maximum 60 µs settling time. The MB88353 is suitable for use in electronic volume controllers, as a replacement for adjustable potentiometers, and in typical D/A converter applications.

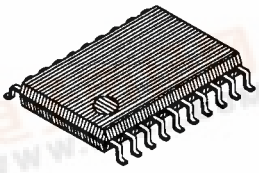
PRELIMINARY



Plastic DIP
(DIP-16P-M04)



Plastic SOP
(FPT-16P-M06)

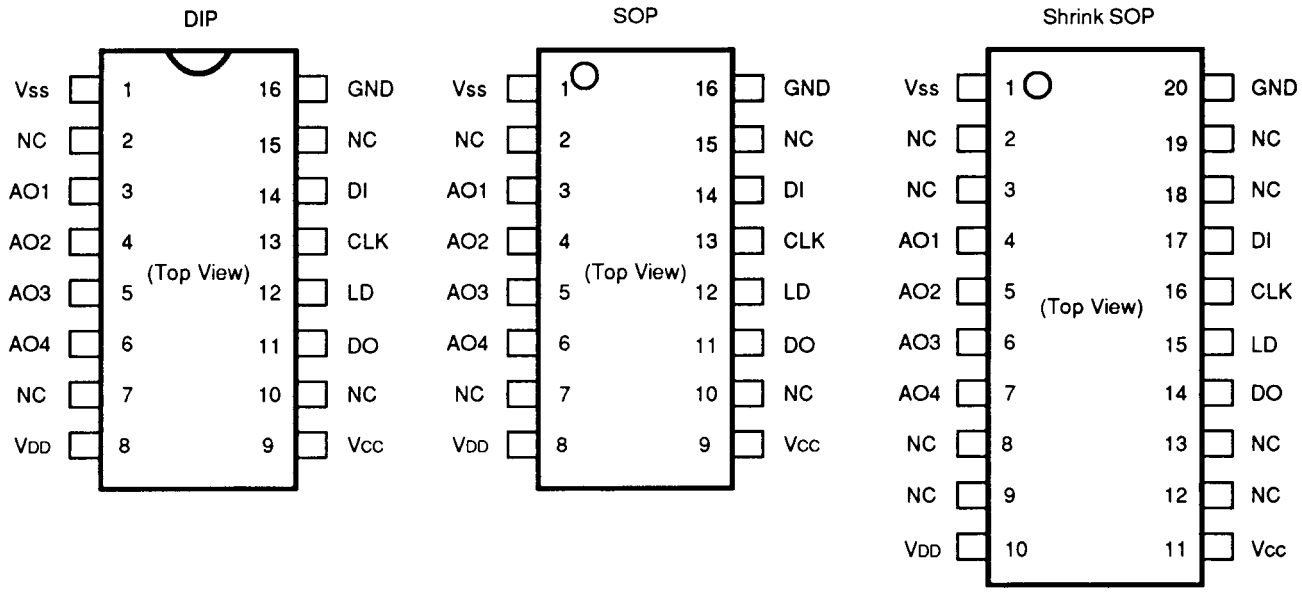


Plastic Shrink SOP
(FPT-20P-M03)

- Conversion method: R-2R resistor ladder
- 12-bit x 4-channel D/A converter
- Maximum 2.5 MHz serial data input
- Serial data output for cascade connection
- Pin compatible with MB88351
- Maximum 60 µs DAC output settling time
- Two separate power supply/ground lines for MCU interface block and D/A converter block
- Single +5 V power supply
- Power consumption: Typical 0.7 mW/channel
- Wide operating temperature range: –20°C to +85°C
- Silicon-gate CMOS process
- Package and ordering information:
  - 16-pin plastic DIP, order as MB88353P
  - 16-pin plastic SOP, order as MB88353PF
  - 20-pin plastic shrink SOP, order as MB88353PVF

This device contains circuitry to protect the inputs against damage due to high static voltages or electric fields. However, it is advised that normal precautions be taken to avoid application of any voltage higher than maximum rated voltages to this high impedance circuit.

Figure 1 Pin Assignment



Note:

NC : No connection

Figure 2 Logic Symbol

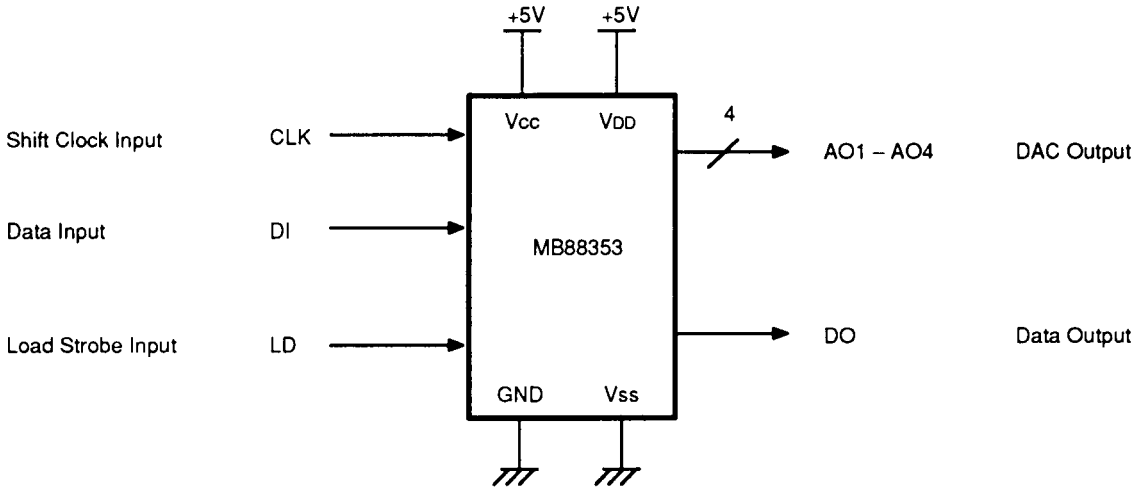
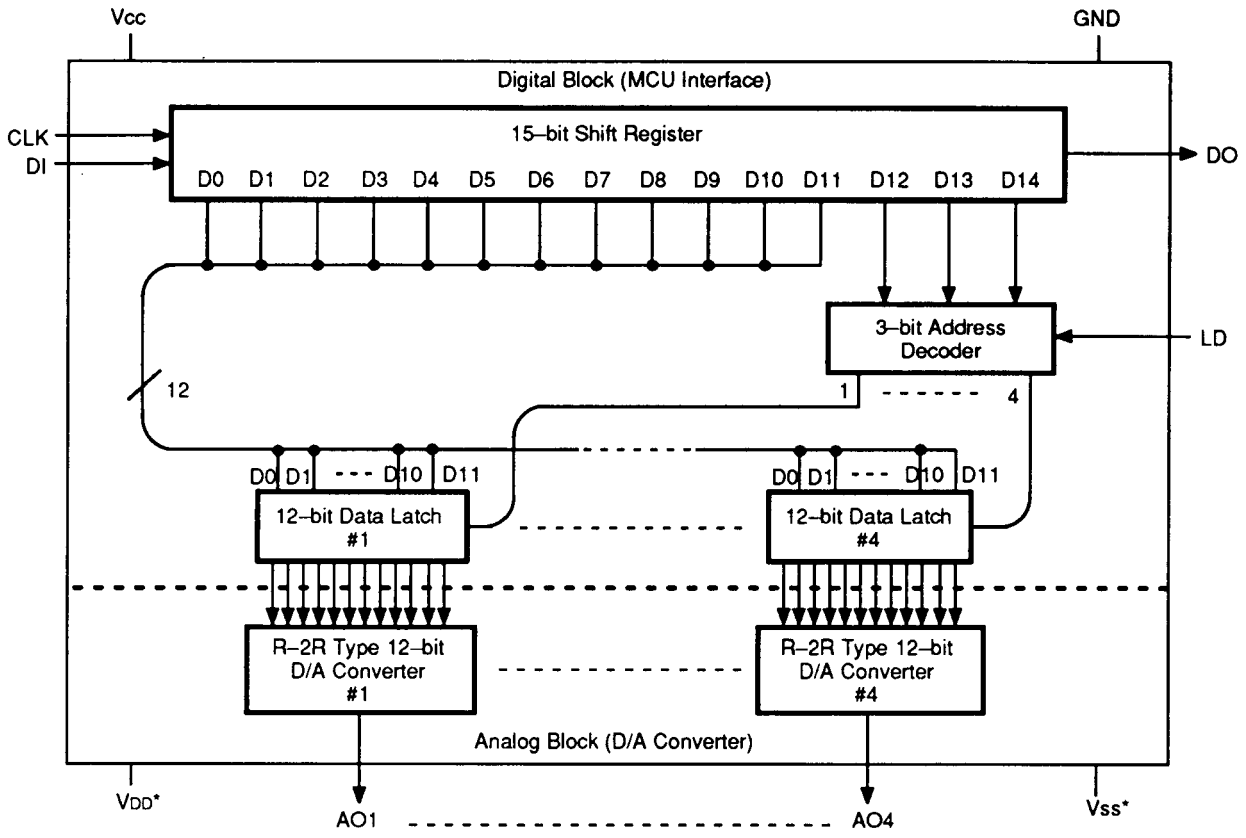


Figure 3 Block Diagram



* : Only for D/A converter block

PIN DESCRIPTION

Figure 1 and Table 1 show the pin assignment and pin description of the MB88353.

Table 1 Pin Description

Symbol	Pin No.		Type	Name & Function
	DIP/SOP	SSOP		
Power Supply				
Vcc	9	11	–	+5V DC power supply pin for the digital block (MCU interface).
GND	16	20	–	Ground pin for the digital block (MCU interface).
V_{DD}	8	10	–	DC power supply pin for the analog block (D/A converter).
Vss	1	1	–	Ground pin for the analog block (D/A converter).
Control Input				
CLK	13	16	I	Shift clock input to the internal 15–bit shift register: At the rising edge of CLK data on the DI pin is shifted into the LSB of the shift register and contents of the shift register are shifted right (to the MSB).
LD	12	15	I	Load strobe input for a 15–bit address/data : A high level on the LD pin latches a 3–bit address (upper 3 bits: D14 to D12) of the internal 15–bit shift register into the internal address decoder, and writes 12–bit data (lower 12 bits: D11 to D0) of the shift register into an internal data latch selected by the latched address.
Data Input/Output				
DI	14	17	I	Serial address/data input to the internal 15–bit shift register: The address/data format is that upper 3 bits (D14 to D12) indicate an address and lower 12 bits (D11 to D0) indicate data. The D14 (MSB) is the first–in bit and D0 (LSB) is the last–in bit.
DO	11	14	O	Serial address/data output from the internal 15–bit shift register: This is an output pin of the MSB bit data of the 15–bit shift register. This pin allows a cascade connection of the device.
DAC Output				
AO1 AO2 AO3 AO4	3 4 5 6	4 5 6 7	O	12–bit resolution D/A converter outputs : 4 channels (AO1 to AO4) of DAC outputs are provided.
Others				
NC	2, 7, 10, 15	2, 3, 8, 9, 12, 13, 18, 19	–	No connection. They must be left open.

FUNCTIONAL DESCRIPTION

OVERVIEW

The MB88353 is an R–2R resistor ladder type, 12–bit resolution digital–to–analog converter (DAC) device. The MB88353 has 4 channels of D/A converters. 12–bit digital data are loaded into internal data latches by individual DAC channel units. The loaded digital data are converted into analog DC voltages through the internal D/A converter in max. 60 µs settling time. For cascade connection, a serial data output is provided.

DEVICE CONFIGURATION

As illustrated in Figure 3, the MB88346B block diagram, the device is comprised of the digital block (MCU interface) and the analog block (D/A converter). The digital block consists of a 12–bit shift register, a 4–bit address decoder, and 12 channels of 8–bit data latches. The analog block includes 12 channels of 8–bit D/A converters. For electrically stable operation the power supply and ground lines are separate between the digital block (MCU interface) operational amplifier output buffers, and the analog block, except for the operational amplifier output buffers.

DEVICE OPERATION

Figure 4 shows the input/output timing. A 15–bit address/data is serially input into the shift register through the DI pin synchronously with the rising edge of CLK. The format of the shift register is shown in Figure 5. The lower 12 bits (D11 to D0) are data bits to be converted, and the upper 3 bits are address bits (D14 to D12) to select a data latch to be written. A high level on the LD pin loads the address decoder with the 3–bit address to select a data latch, and writes the 12–bit data into a selected data latch. Figure 6 shows the data latch address map, and Table 2 lists the address decoding. 12–bit data written into individual data latches are converted into analog DC voltages, dividing the supply voltage |V_{DD}–Vss| through R–2R resistor ladders of D/A converters. Figure 7 shows a configuration of the R–2R resistor ladder D/A converter, and Table 3 lists the analog DC voltages corresponding to each digital data.

Figure 4 Input/Output Timing

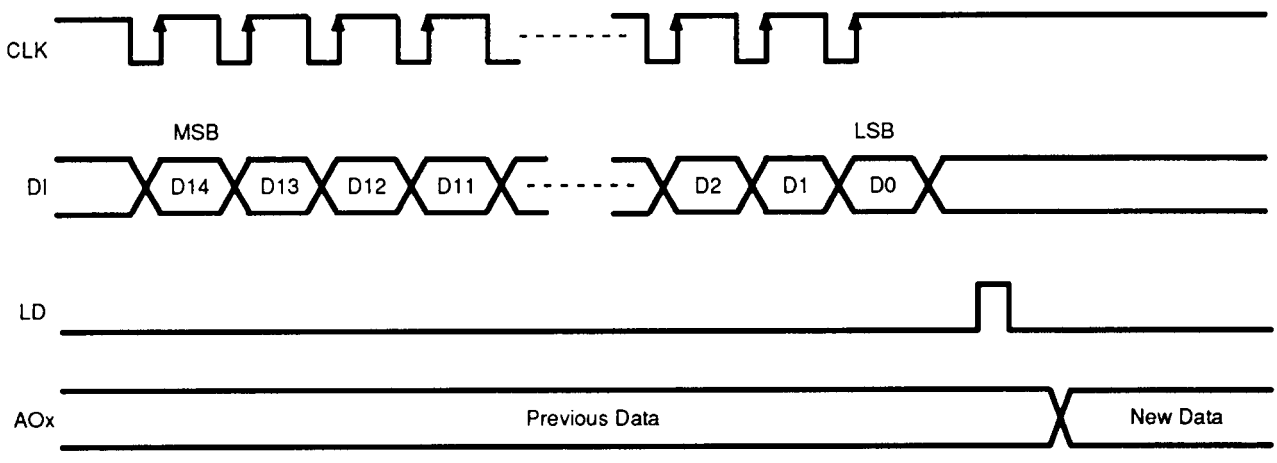


Figure 5 Shift Register Format

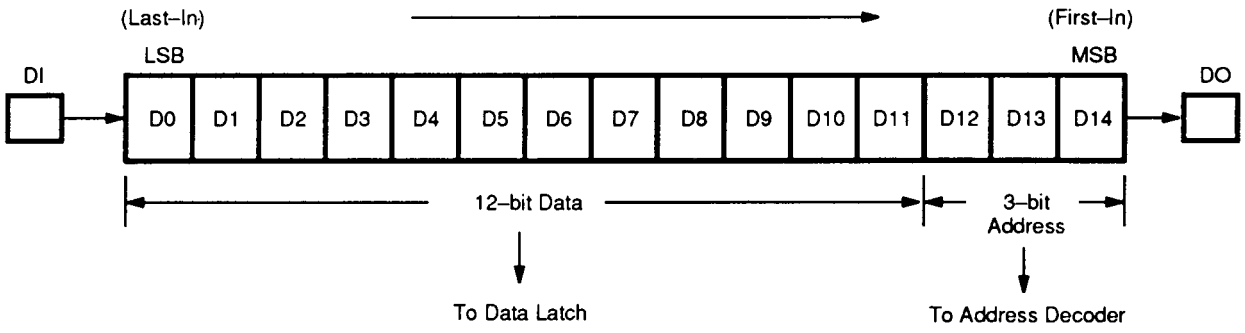


Figure 6 Data Latch Address Map

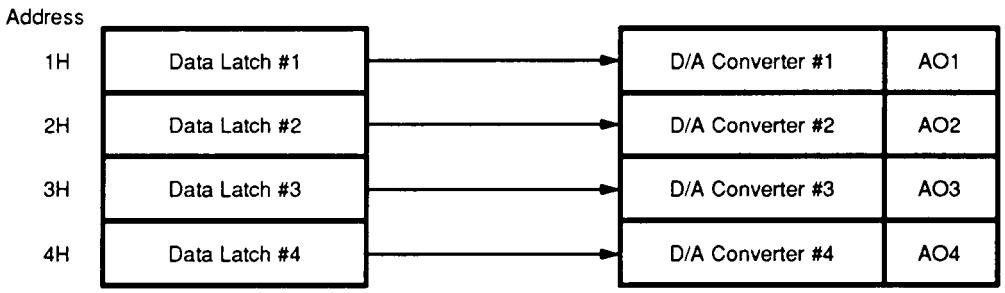


Figure 7 Configuration of R–2R Resistor Ladder D/A Converter

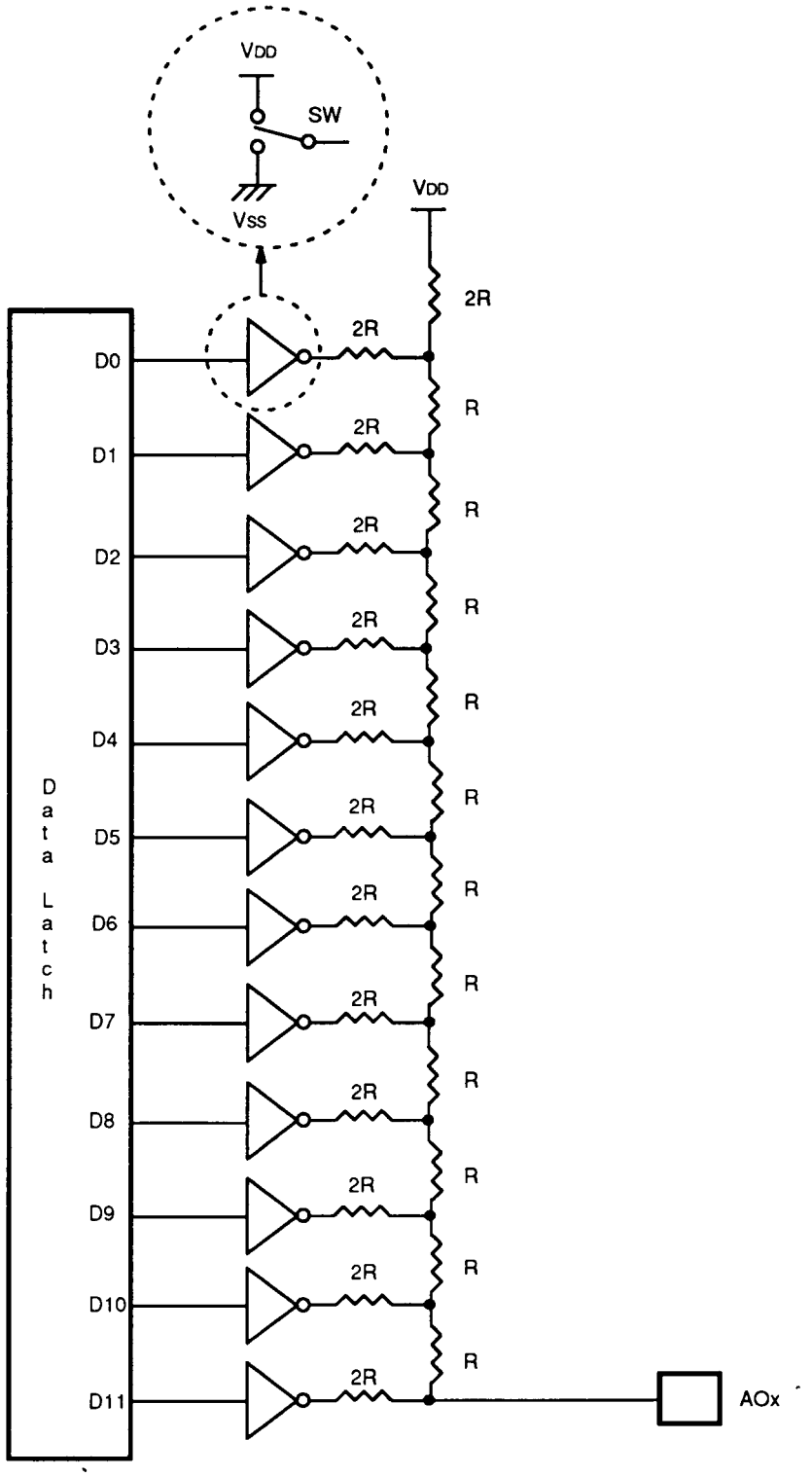


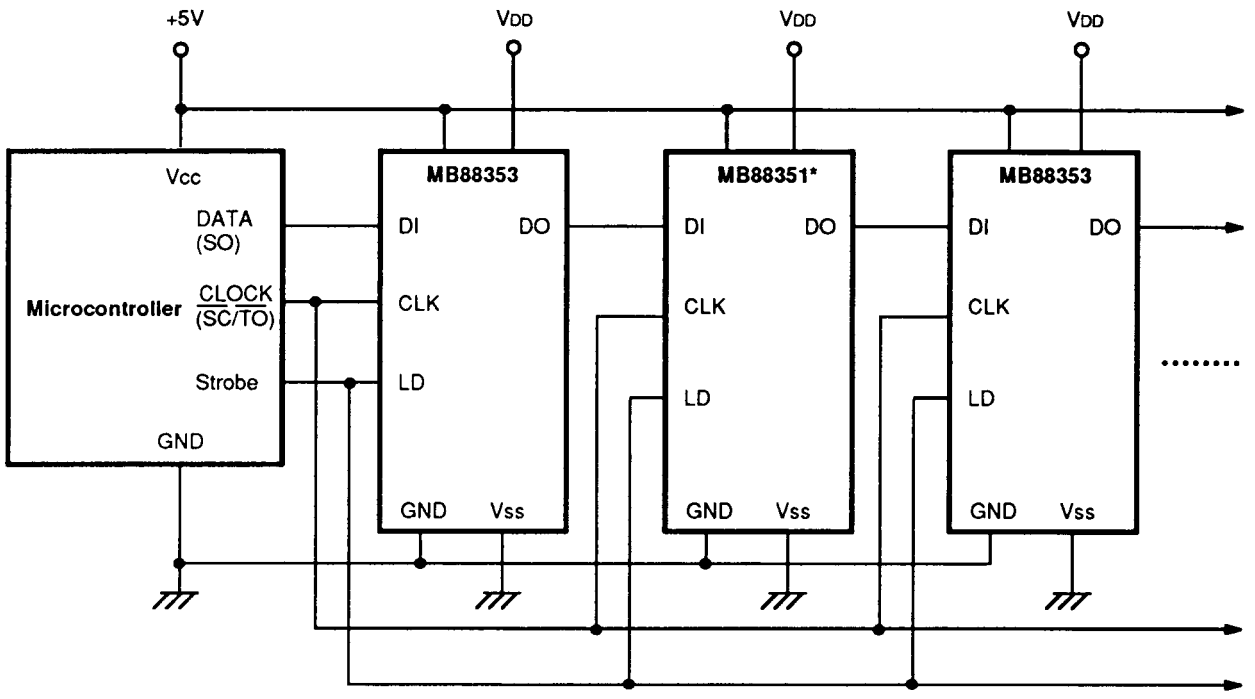
Table 2 Address Decoding

Address			Data Latch Selected
D12	D13	D14	MB88353
0	0	0	Deselected
0	0	1	Data Latch #1
0	1	0	Data Latch #2
0	1	1	Data Latch #3
1	0	0	Data Latch #4
1	0	1	Deselected
1	1	0	Deselected
1	1	1	Deselected

Table 3 Data Conversion

Data												DAC Output Level
D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0	AOx
0	0	0	0	0	0	0	0	0	0	0	0	≈ Vss
0	0	0	0	0	0	0	0	0	0	0	1	≈ (VDD – Vss) x 1/4095 + Vss
0	0	0	0	0	0	0	0	0	0	1	0	≈ (VDD – Vss) x 2/4095 + Vss
0	0	0	0	0	0	0	0	0	0	1	1	≈ (VDD – Vss) x 3/4095 + Vss
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
1	1	1	1	1	1	1	1	1	1	0	0	≈ (VDD–Vss) x 4092/4095+Vss
1	1	1	1	1	1	1	1	1	1	0	1	≈ (VDD–Vss) x 4093/4095+Vss
1	1	1	1	1	1	1	1	1	1	1	0	≈ (VDD–Vss) x 4094/4095+Vss
1	1	1	1	1	1	1	1	1	1	1	1	≈ VDD

Figure 8 Cascade Connection Example

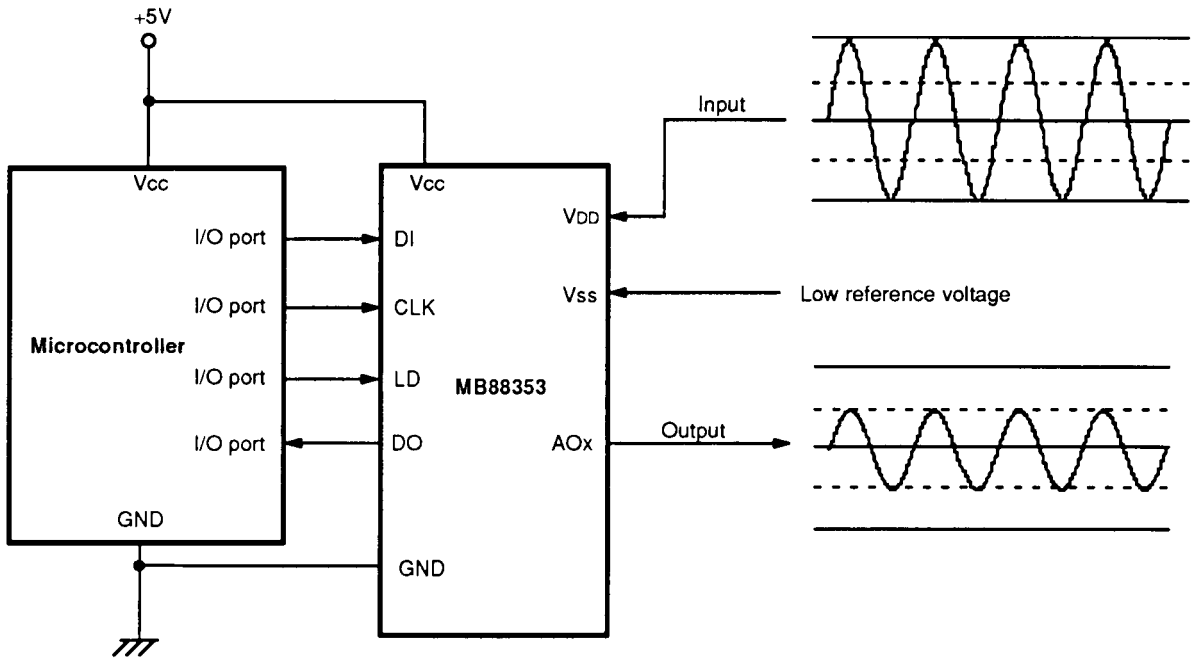


* : MB88353 can be used mixed with MB88351.

APPLICATION DESCRIPTION

The MB88346B is suitable for use in electronic volume controllers, as a replacement for adjustable potentiometers, and in typical D/A converter applications. Figure 9 illustrates an application example for a gain control.

Figure 9 Application Example – Gain Control



ELECTRICAL CHARACTERISTICS

ABSOLUTE MAXIMUM RATINGS (See NOTE)

Parameter	Symbol	Rating			Unit	Condition
		Min	Typ	Max		
Supply Voltage	Vcc	−0.3		7.0	V	TA = +25°C GND = 0 V VDD ≤ Vcc,
	VDD	−0.3		7.0	V	
Input Voltage	VIN	−0.3		Vcc+0.3	V	TA = +25°C GND = 0 V
Output Voltage	VOUT	−0.3		Vcc+0.3	V	
Power Dissipation	PD			250	mW	
Operating Ambient Temperature	TA	−20		+85	°C	
Storage Temperature	TSTG	−55		+150	°C	

NOTE: Permanent device damage may occur if the above ABSOLUTE MAXIMUM RATINGS are exceeded. Functional operation should be restricted to the conditions as detailed in the operational sections of this data sheet. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Value			Unit	Condition
		Min	Typ	Max		
Supply Voltage (for Digital Block)	Vcc	4.5	5.0	5.5	V	Vcc≥VDD
	GND		0		V	
Supply Voltage (for Analog Block)	VDD	2.0		Vcc	V	Vcc≥VDD, VDD−Vss≥2.0V
	Vss	GND		Vcc−2.0	V	
Operating Ambient Temperature	TA	−20		+85	°C	

DC CHARACTERISTICS

(Recommended operating conditions unless otherwise noted.)

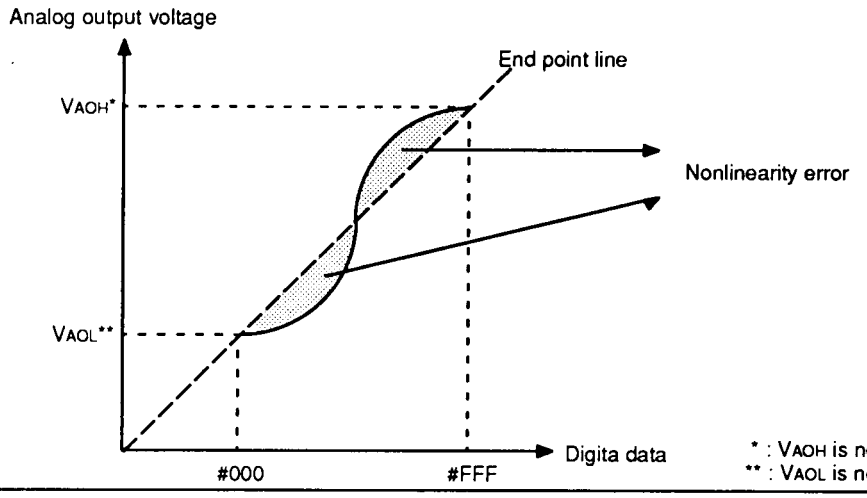
Digital Block (MCU Interface)

Parameter	Symbol	Value			Unit	Condition
		Min	Typ.	Max		
Active Supply Current (Vcc)	Icc		0.3	0.5	mA	CLK = 1MHz, Unloaded
Input Leakage Current (CLK, DI, and LD)	I_{ILK}	–10		+10	µA	V_{IN} = 0 to Vcc
Input Low Voltage (CLK, DI, and LD)	V_{IL}			0.2•Vcc	V	
Input High Voltage (CLK, DI, and LD)	V_{IH}	0.8•Vcc			V	
Output Low Voltage (DO)	V_{OL}			0.4	V	I_{OL} = +2.5 mA
Output High Voltage (DO)	V_{OH}	Vcc–0.4			V	I_{OH} = –400 µA

Analog Block (D/A Converters)

Parameter	Symbol	Value			Unit	Condition
		Min	Typ	Max		
Analog Supply Voltage (V_{DD})	V_{DD}	2.0		Vcc	V	V_{DD}–Vss≥2.0V
	Vss	GND		Vcc–2.0	V	
Supply Current (V_{DD})	I_{DD}		0.2	0.4	mA	Unloaded
Min. Analog Output Voltage (AOx)	V_{AOL}	Vss–0.005		Vss+0.005	V	Unloaded, Vss = 0V, Digital data=#000
Max. Analog Output Voltage (AOx)	V_{AOH}	V_{DD}–0.005		V_{DD}+0.005	V	Unloaded, V_{DD} = Vcc, Digital data=#FFF
Resolution (AOx)	Res		12		Bits	
Monotonicity (AOx)	Rem		10		Bits	Unloaded
Offset Error (AOx)	E_O	–5.0		+5.0	mV	Unloaded,
Nonlinearity Error (AOx)	E_{NL}	–8.0		+8.0	LSB	Unloaded, Vss≥0.1V, V_{DD}≤Vcc–0.1V See Figure 10.

Figure 10 Definition of Linearity Error



AC CHARACTERISTICS

(Recommended operating conditions unless otherwise noted.)

Parameter	Symbol	Value		Unit	Condition
		Min	Max		
Clock Low Time	t_{CKL}	200		ns	
Clock High Time	t_{CKH}	200		ns	
Clock Rise Time	t_{Cr}		200	ns	
Clock Fall Time	t_{Cf}		200	ns	
Data Setup Time	t_{DCH}	30		ns	
Data Hold Time	t_{CHD}	60		ns	
Load Strobe High Time	t_{LDH}	100		ns	
Load Strobe Setup Time	t_{CHL}	200		ns	
Load Strobe Hold Time	t_{LDC}	100		ns	
DAC Output Settling Time	t_{LDD}		60	µs	Unloaded
Data Output Delay Time	t_{DO}	70	350	ns	**C_L = 20 pF (Min.), 100 pF (Max.), See Figure 11.

Figure 11 AC Test Conditions

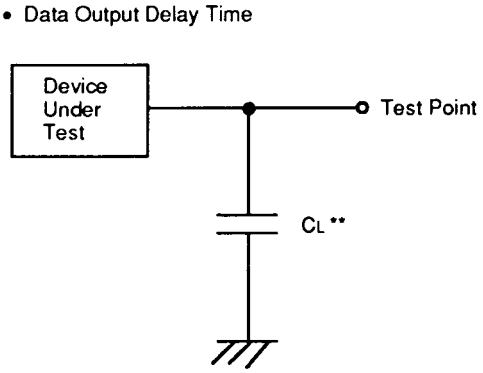


Figure 12 Input/Output Timing

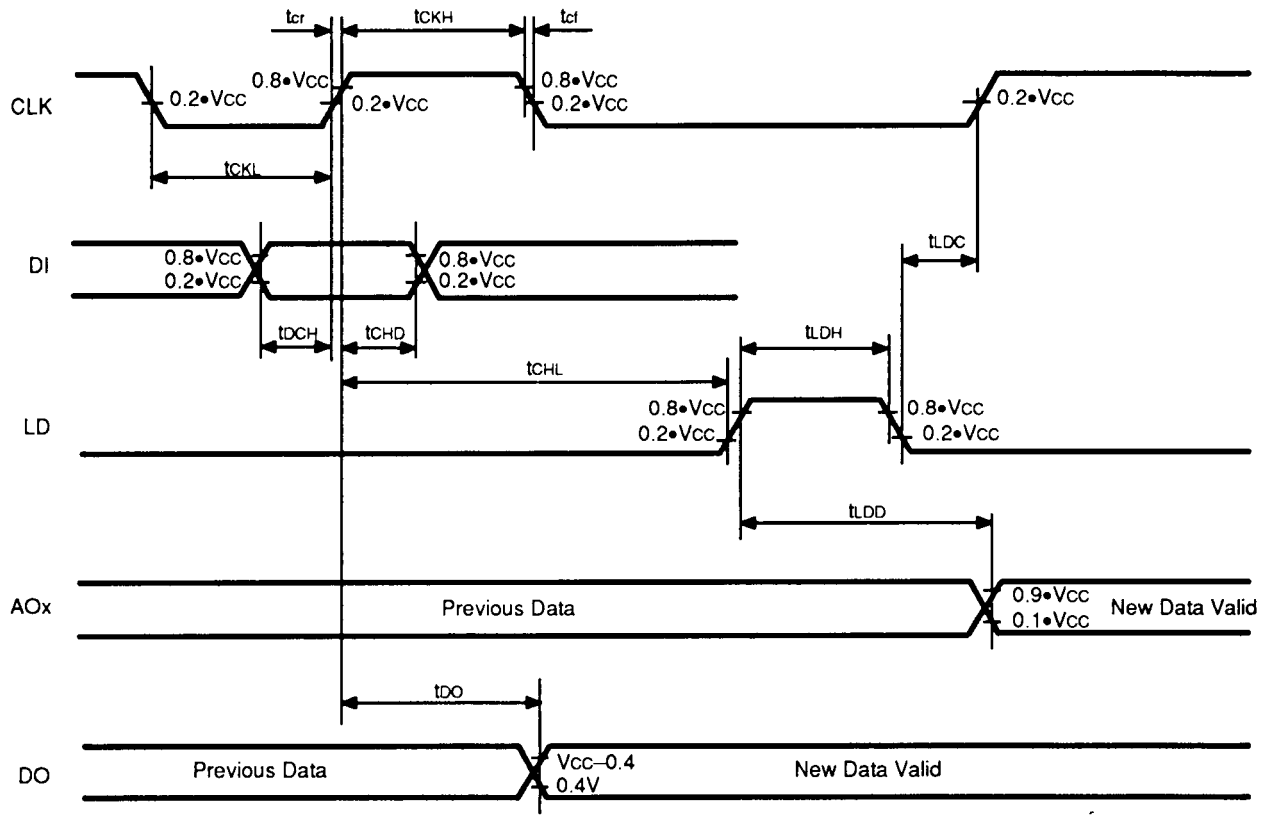
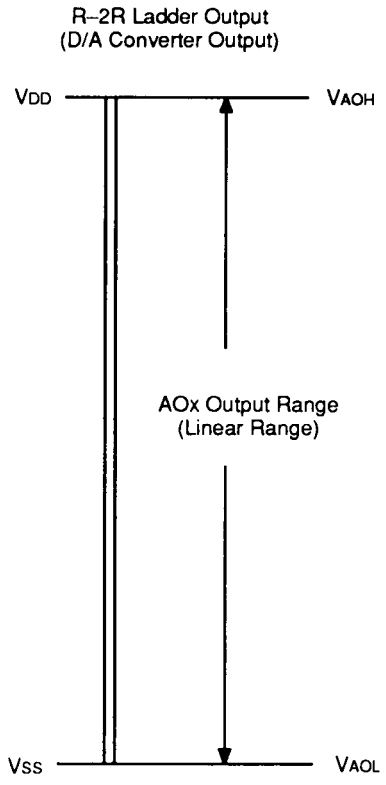


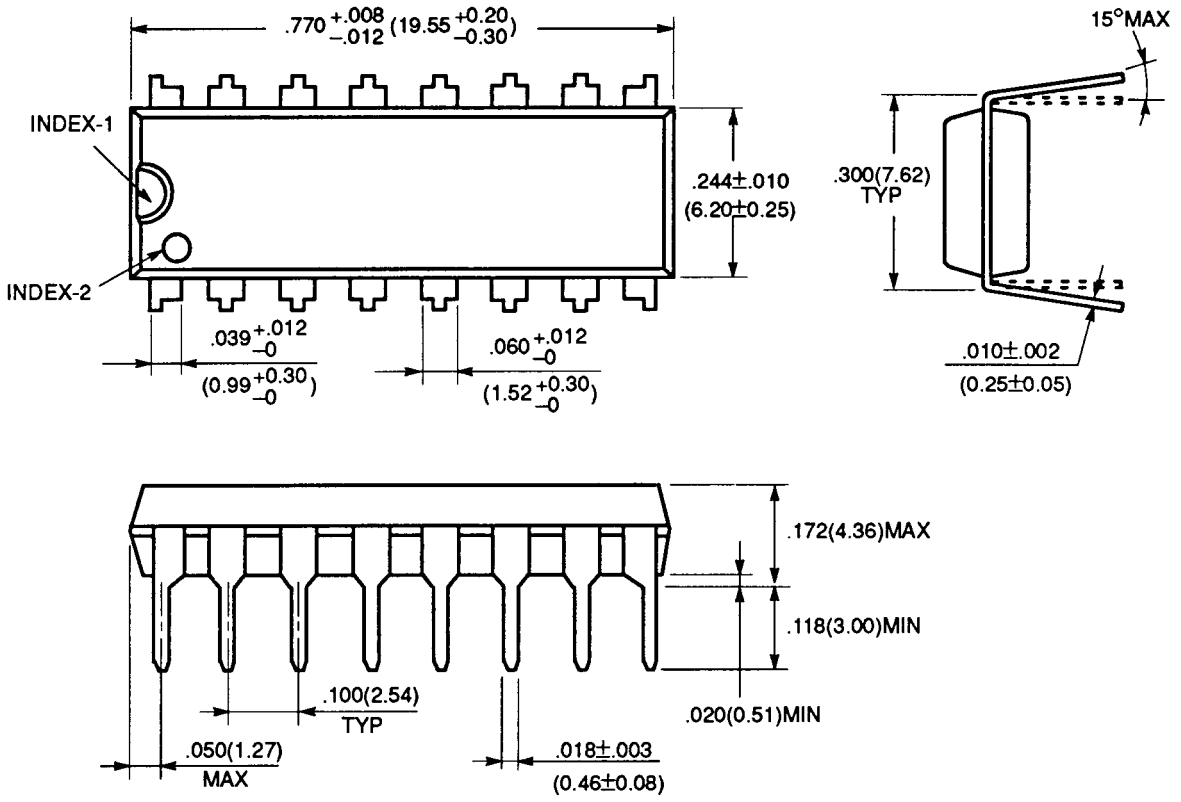
Figure 13 Analog Output Voltage Range



PACKAGE DIMENSIONS

MB88353P

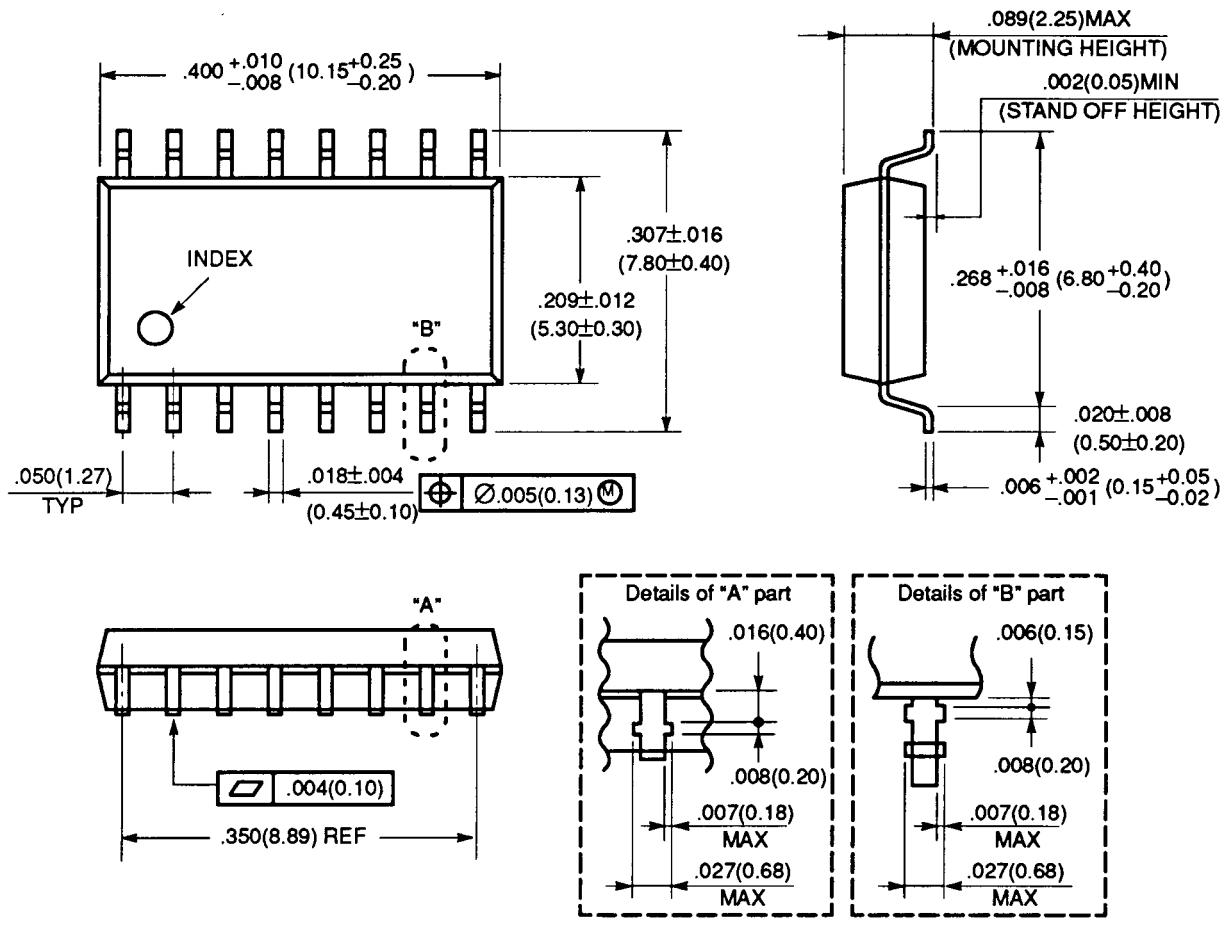
16-LEAD PLASTIC DUAL IN-LINE PACKAGE
(CASE No.: DIP-16P-M04)



Dimensions in
inches (millimeters)

MB88353PF

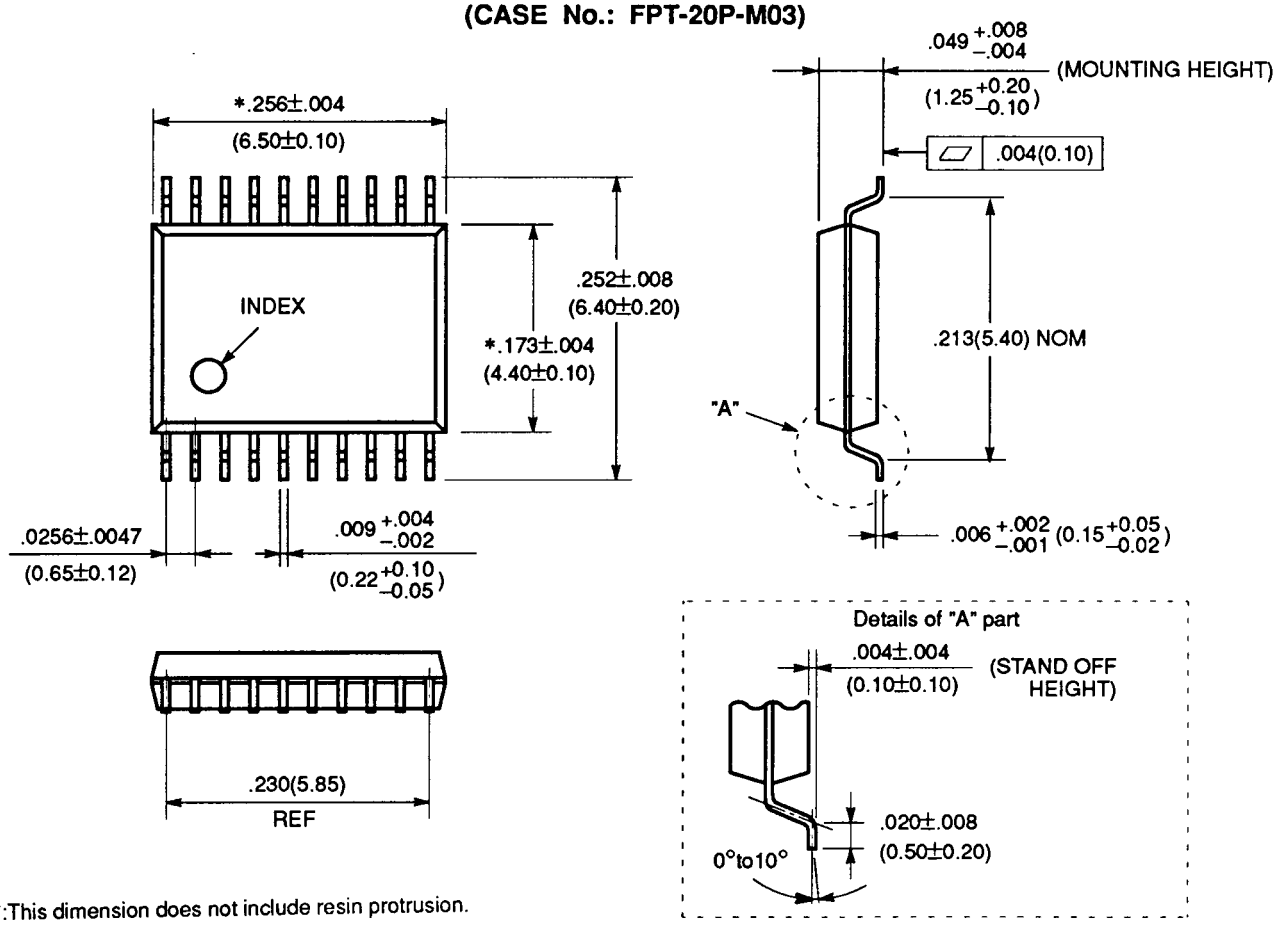
16-LEAD PLASTIC FLAT PACKAGE
(CASE No.: FPT-16P-M06)



Dimensions in
inches (millimeters)

MB88353PFV

20-LEAD PLASTIC FLAT PACKAGE
(CASE No.: FPT-20P-M03)



*:This dimension does not include resin protrusion.

Dimensions in inches (millimeters)

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