

ASSP

# Single Chip 8-Bit A/D and 9-Bit D/A Converter

## MB40168/MB40178

### DESCRIPTION

The Fujitsu MB40168 and MB40178 are high speed, low power single chip A/D and D/A converters designed for video processing applications. The A/D converter has a resolution of 8 bits while the D/A converter has 9-bit resolution. They are fabricated in Fujitsu's advanced bipolar technology, and housed in a 48-pin plastic shrink DIP or 44-pin plastic QFP package.

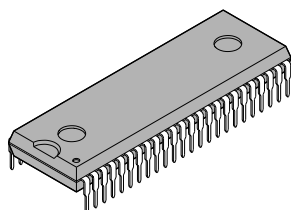
### FEATURES

- Resolution                                   A/D: 8 bits  
  D/A: 9 bits
- Conversion Rate                           A/D: Max. 20 MSPS  
  D/A: Max. 40 MSPS
- Linearity Error                             A/D: Max. + 0.3%  
  D/A: Max. + 0.2%
- On-chip reference voltage generator (resistor divided method) and clamp circuit
- Analog Input Voltage                    3 to 5 V without clamp circuit  
  0 to 3 V in 1.95 V<sub>P-P</sub> clamp circuit
- Analog Output Voltage                   3 to 5 V

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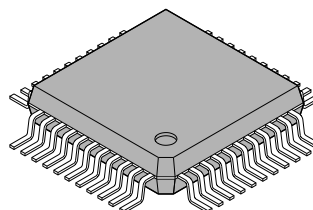
### PACKAGES

48 pin, Plastic SH-DIP



(DIP-48P-M01)

44 pin, Plastic QFP



(FPT-44P-M11)

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.

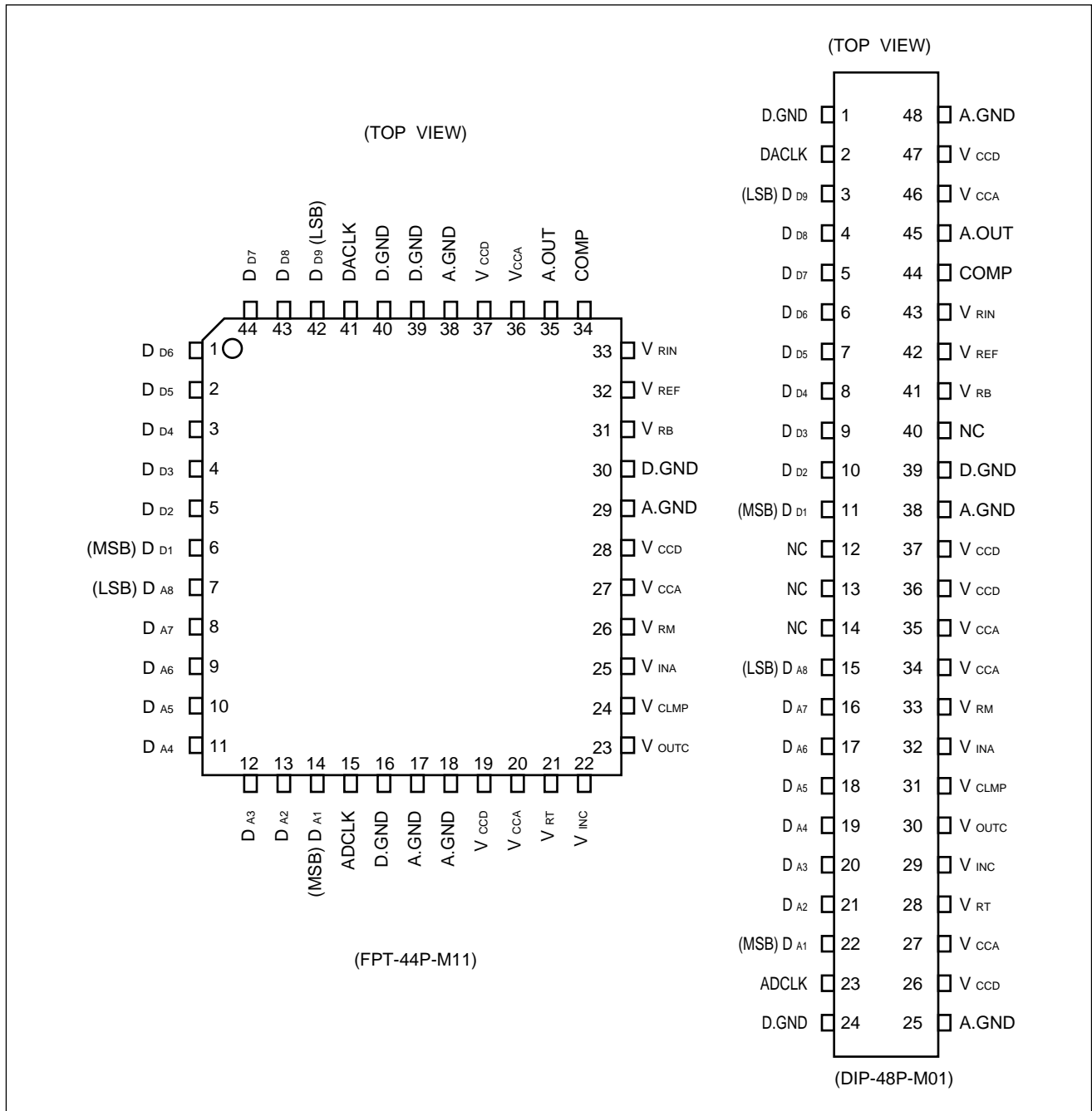
# MB40168/MB40178

(Continued)

- Digital Input/Output Interface
  - Power Supply Voltage
  - Power Dissipation
  - Package Options
- TTL Levels  
 + 5.0 V single power supply  
 Typ. 350 mW  
 48-pin Plastic Shrink DIP/  
 44-pin Plastic QFP Package

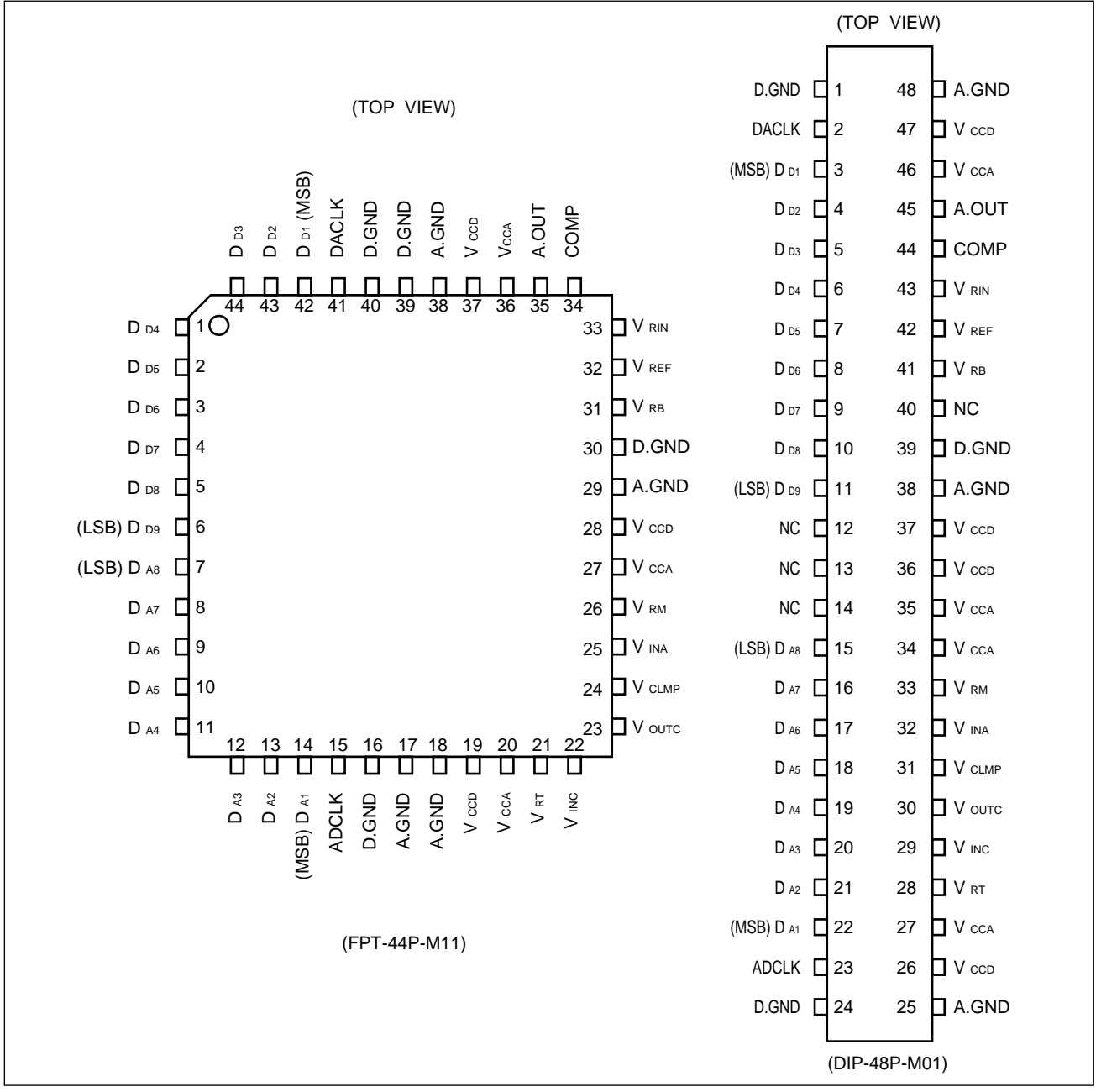
## PIN ASSIGNMENTS

- MB40168



# MB40168/MB40178

• MB40178



# MB40168/MB40178

## ■ PIN DESCRIPTION

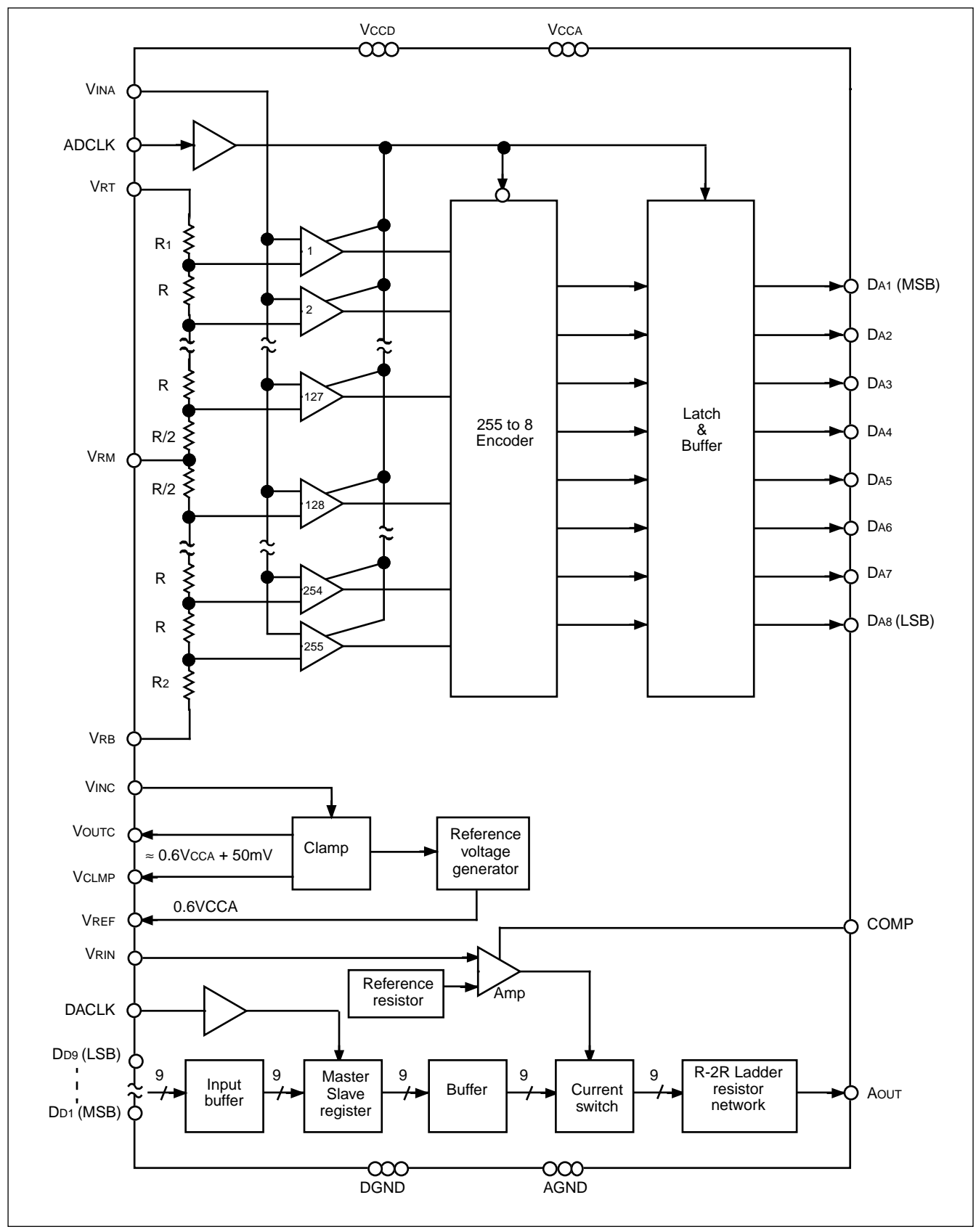
Symbol	Pin No.		I/O	Name & Function
	QFP-44	SH-DIP-48		
VCCD	19, 28, 37	26, 36, 37, 47	—	Digital Power Supply pins (+ 5 V).
VCCA	20, 27, 36	27, 34, 35, 46	—	Analog Power Supply pins (+ 5 V).
DGND	16, 30, 39, 40	1, 24, 39	—	Digital Ground (0 V). These pins should be connected to the analog ground on the application system.
AGND	17, 18, 29, 38	25, 38, 48	—	Analog Ground (0 V). These pins should be connected to the analog ground on the application system.
DA8 - DA1	7 - 14	15 - 22	O	ADC Digital Output pins. TTL level.
ADCLK	15	23	I	ADC Clock Input pin. TTL level.
VRT	21	28	I	ADC Reference Voltage Input pin. (5 V Input)
VINC	22	29	I	Sync Tip Clamp Circuit Analog Input pin. (0 - 3 V, 1.95 VP-P). When a clamp circuit is not used, this pin is connected to ground.
VOUTC	23	30	O	Clamp Circuit Analog Output pin. It is used by adding a capacitor (1 $\mu$ F or more) between VCLMP and VOVTC pins. When a clamp circuit is not used, this pin is left open.
VCLMP	24	31	O	Clamp Voltage Output pin (3.05V Output). When a clamp circuit is not used, this pin is left open.
VINA	25	32	I	ADC Analog Signal Input pin. (3 - 5 V)
VRM	26	33	—	ADC Middle Reference Voltage Monitor pin. (Mid of VRT - VRB is set to this pin). Normally this pin is left open.
VRB	31	41	I	ADC Reference Voltage Input pin. (3 V)
VREF	32	42	O	Reference Voltage Output pin. (Resistor Divider, 3 V) By connecting this pin to VRB pin, 3V Voltages are generated. When a reference voltage is not used, this pin is left open.
VRIN	33	43	I	DAC Reference Voltage Input pin (3 V)
COMP	34	44	—	Phase Compensation Capacitor pin. (Capacitor greater than 0.1 $\mu$ F should be connected between this pin and Analog Ground.)
AOUT	35	45	O	Analog Signal Output pin
DACLK	41	2	I	DAC Clock Input pin. TTL level.
DD9 - DD1	1 - 6 *1 42 - 44	3 - 11*2	I	DAC Digital Data Input pins. TTL level.

\*1: MB40168 (MSB: 6 pin, LSB: 42 pin), MB40178 (MSB: 42 pin, LSB: 6 pin)

\*2: MB40168 (MSB: 11 pin, LSB: 3 pin), MB40178 (MSB: 3 pin, LSB: 11 pin)

# MB40168/MB40178

## ■ BLOCKDIAGRAM



# MB40168/MB40178

## ■ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating	Unit
Power supply voltage	V <sub>CCA</sub> , V <sub>CCD</sub>	−0.5 to 7.0	V
Analog input voltage	V <sub>INA</sub>	−0.5 to V <sub>CC</sub> + 0.5	V
Reference voltage	V <sub>RT</sub> , V <sub>RB</sub> , V <sub>RIN</sub>	−0.5 to V <sub>CC</sub> + 0.5	V
Clamp circuit input voltage	V <sub>INC</sub>	−0.5 to V <sub>CC</sub> + 0.5	V
Digital input voltage	V <sub>IND</sub>	−0.5 to 7.0	V
Storage temperature	T <sub>STG</sub>	−55 to +125	°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
			Min.	Typ.	Max.	
Power supply voltage *1		VCCA, VCCD	4.75	5.00	5.25	V
Clamp circuit input voltage *2		VINC	0	—	3	V
Analog input voltage		VINA	VRB	—	VRT	V
ADC reference voltage *3	Top	VRT	VCCA - 0.1	VCCA	VCCA + 0.1	V
	Bottom	VRB	2.75	3.0	3.25	V
DAC reference voltage		VCCA - VRIN	0.7	2.0	2.2	V
		VRIN	2.65	3.0	4.3	V
Digital input high voltage		VIHD	2.0	—	—	V
Digital input low voltage		VILD	—	—	0.8	V
Digital output high current		IOH	-400	—	—	μA
Digital output low current		IOL	—	—	1.6	mA
Clock frequency	A/D	fCLKAD	—	—	20	MHz
	D/A	fCLKDA	—	—	40	MHz
Minimum high clock pulse width	A/D	tWHAD	22.5	—	—	ns
	D/A	tWHDA	10.5	—	—	ns
Minimum Low clock pulse width	A/D	tWLAD	22.5	—	—	ns
	D/A	tWLAD	10.5	—	—	ns
Set up time		tsu	10	—	—	ns
Hold time		th	4	—	—	ns
Clamp capacitance		CCLMP	1	—	—	μF
Phase compensation capacitance		CCOMP	0.1	—	—	μF
Ambient operating temperature		Ta	-20	—	+70	°C

\*1: VCCA and VCCD must be used in the same voltage level.

\*2: VINC must have an amplitude of VRT - VCLMP.

\*3: VRT - VRB must have 2.0V±0.1V.

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## ■ ELECTRICAL CHARACTERISTICS

### 1. DC Characteristics

- Analog Block

( $V_{CCA} = V_{CCD} = 4.75 \text{ V to } 5.25 \text{ V}$ ,  $T_a = -20 \text{ }^\circ\text{C to } +70 \text{ }^\circ\text{C}$ )

Parameter	Symbol	Condition	Value			Unit
			Min.	Typ.	Max.	
ADC resolution	—	—	—	8	—	bits
DAC resolution	—	—	—	9	—	bits
ADC linearity error	LE <sub>AD</sub>	DC accuracy $V_{CCA} = V_{CCD} = 5.0 \text{ V}$	—	$\pm 0.15$	$\pm 0.3$	%
DAC linearity error	LE <sub>DA</sub>		—	$\pm 0.1$	$\pm 0.2$	%
Analog input equivalent impedance	R <sub>INA</sub>	$R_{INA} = \frac{V_{RT} - V_{RB}}{I_{HA} - I_{LA}}$	0.3	1.3	—	M $\Omega$
Analog input capacitance	C <sub>INA</sub>	$f_{INA} = 1 \text{ MHz}$	—	40	—	pF
Analog input high current	I <sub>HA</sub>	$V_{INA} = V_{RT}$	—	—	45	$\mu\text{A}$
Analog input low current	I <sub>LA</sub>	$V_{INA} = V_{RB}$	—	—	40	$\mu\text{A}$
Reference output voltage	V <sub>REF</sub>	V <sub>REF</sub> , V <sub>RB</sub> , V <sub>RIN</sub> shorted together	$0.6V_{CCA} - 0.1$	$0.6V_{CCA}$	$0.6V_{CCA} + 0.1$	V
Clamp voltage	V <sub>CLMP</sub>	—	—	V <sub>REF</sub> + 50 mV	—	V
ADC reference current	I <sub>RB</sub>	—	-8.5	-5.5	-3.0	mA
DAC reference current	I <sub>RIN</sub>	V <sub>RIN</sub> = 3.000 V	—	—	10	$\mu\text{A}$
Clamp circuit input current	I <sub>INC</sub>	V <sub>INC</sub> = 0 V	-600	-200	—	$\mu\text{A}$
Full scale output voltage	V <sub>OFS</sub>	—	$V_{CCA} - 20\text{mV}$	$V_{CCA}$	—	V
Zero scale output voltage	V <sub>OZS</sub>	$V_{CCA} = 5.00 \text{ V}$ $V_{CCD} = 5.00 \text{ V}$ $V_{RIN} = 3.000 \text{ V}$	2.934	3.004	3.072	V
Output impedance	R <sub>O</sub>	T <sub>a</sub> = +25 °C	192	240	288	$\Omega$
Supply current	I <sub>CC</sub>	—	—	70	125	mA



## MB40168/MB40178

- Digital Block

(V<sub>CCA</sub> = V<sub>CCD</sub> = 4.75 V to 5.25 V, T<sub>a</sub> = -20 °C to +70 °C)

Parameter	Symbol	Condition	Value			Unit
			Min.	Typ.	Max.	
Digital output high voltage	V <sub>OHD</sub>	I <sub>OH</sub> = -400 μA	2.7	—	—	V
Digital output low voltage	V <sub>OLD</sub>	I <sub>OL</sub> = 1.6 mA	—	—	0.4	V
Digital input high voltage	V <sub>IHD</sub>	—	2.0	—	—	V
Digital input low voltage	V <sub>ILD</sub>	—	—	—	0.8	V
Digital input high current	I <sub>IHD</sub>	V <sub>IHD</sub> = 2.7 V	—	—	20	μA
Digital input low current	I <sub>ILD</sub>	V <sub>ILD</sub> = 0.4 V	-100	—	—	μA

## 2. AC CHARACTERISTICS

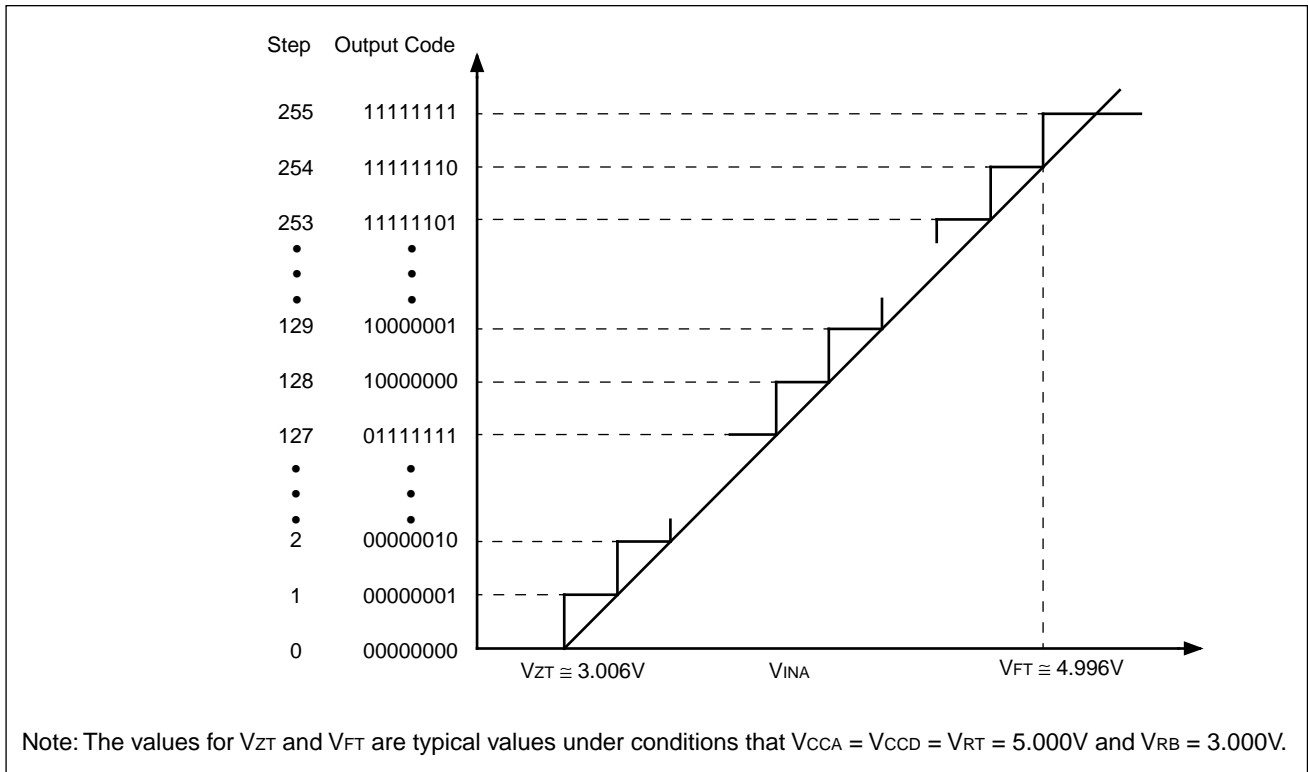
(V<sub>CCA</sub> = V<sub>CCD</sub> = 4.75 V to 5.25 V, T<sub>a</sub> = -20 °C to +70 °C)

Parameter		Symbol	Condition	Value			Unit
				Min.	Typ.	Max.	
Maximum conversion rate	A/D	f <sub>SAD</sub>	—	20	—	—	MSPS
	D/A	f <sub>SDA</sub>	—	40	—	—	MSPS
Digital output delay time		t <sub>pd AD</sub>	—	8	15	30	ns
Analog output delay time		t <sub>pd DA</sub>	CL = 15 pF Terminating resistor A <sub>OUT</sub> = 240 Ω	—	10	—	ns
Analog output rise time		t <sub>r</sub>		—	5	—	ns
Analog output fall time		t <sub>f</sub>		—	5	—	ns
Settling time		t <sub>set LH</sub> , t <sub>set HL</sub>		—	16	—	ns

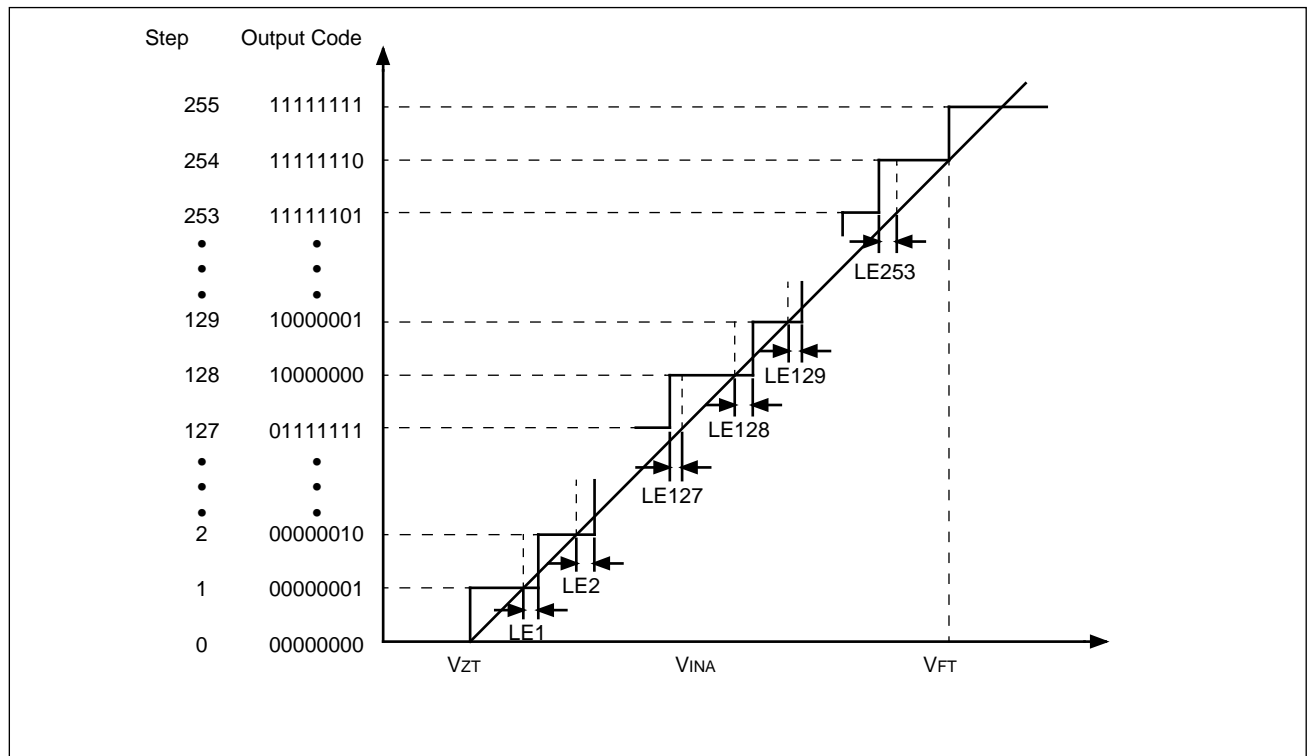
# MB40168/MB40178

## LINEARITY ERROR OF A/D CONVERSION

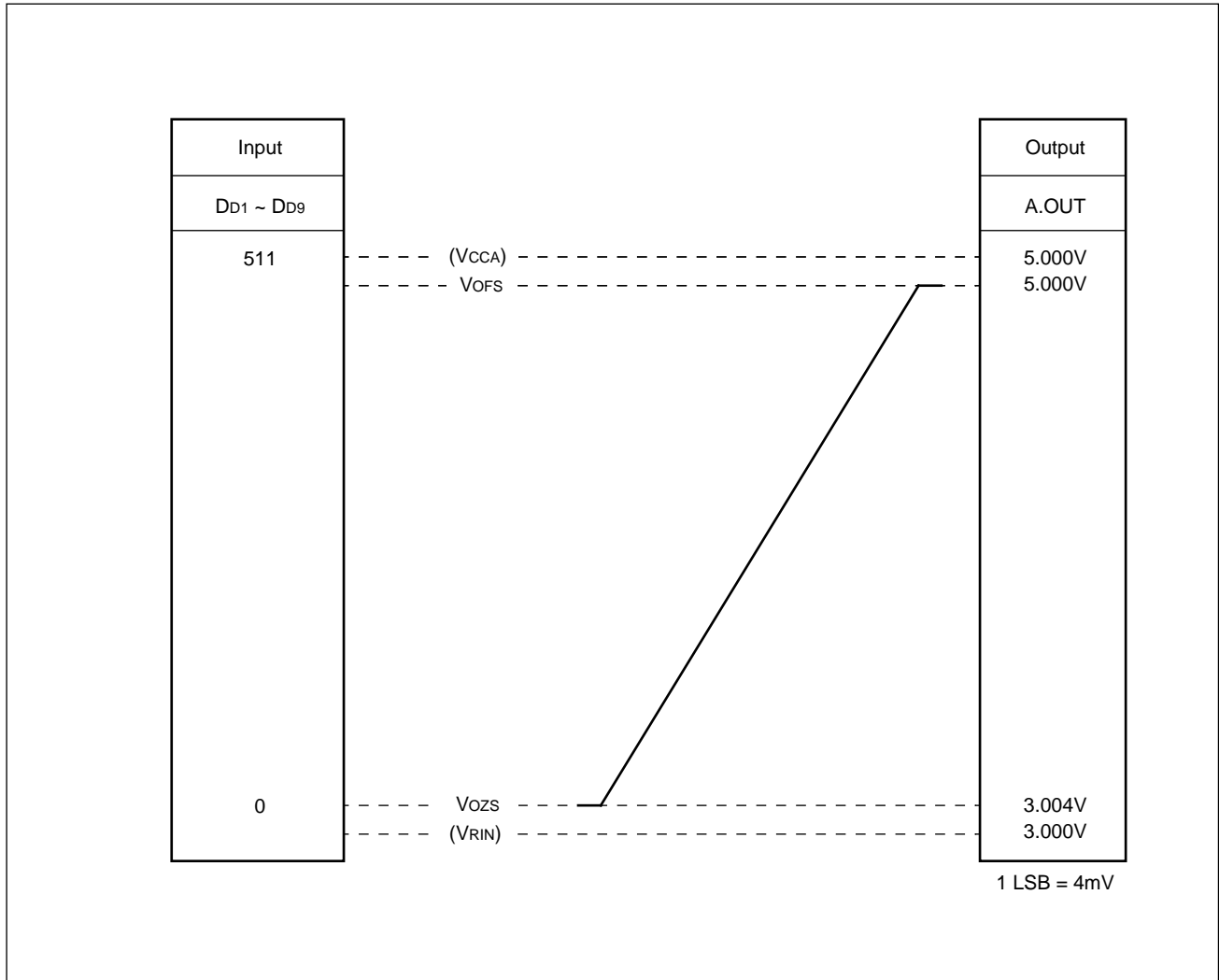
### • Ideal Characteristic



### • Actual Characteristic



## ■ OUTPUT VOLTAGE CHARACTERISTIC OF D/A CONVERTER BLOCK



## ■ CALCULATION OF DAC OUTPUT VOLTAGE WHEN THE IDEAL CONVERSION IS PERFORMED

$$AOUT_N = V_{CCA} - \frac{511-N}{512} \times (V_{CCA} - V_{RIN})$$

(N: Digital code (0 ~ 511))

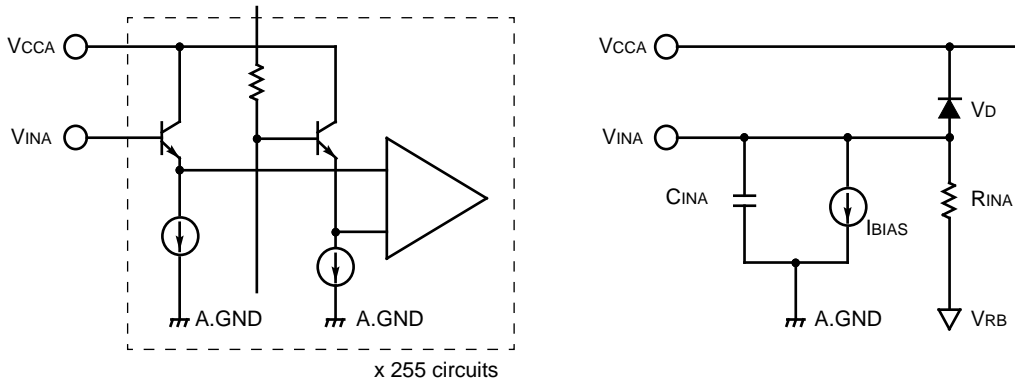
$$V_{OFS} = V_{CCA}$$

$$V_{OZS} = V_{CCA} - \frac{511}{512} \times (V_{CCA} - V_{RIN})$$

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## ■ EQUIVALENT CIRCUITS OF ADC BLOCK

### • Analog Input Equivalent Circuit



CINA: Junction Capacitance of non-linear emitter follower

RINA: Linear resistance model of input current by the comparator switching

$V_{INA} < V_{VRB}$ :  $\infty$

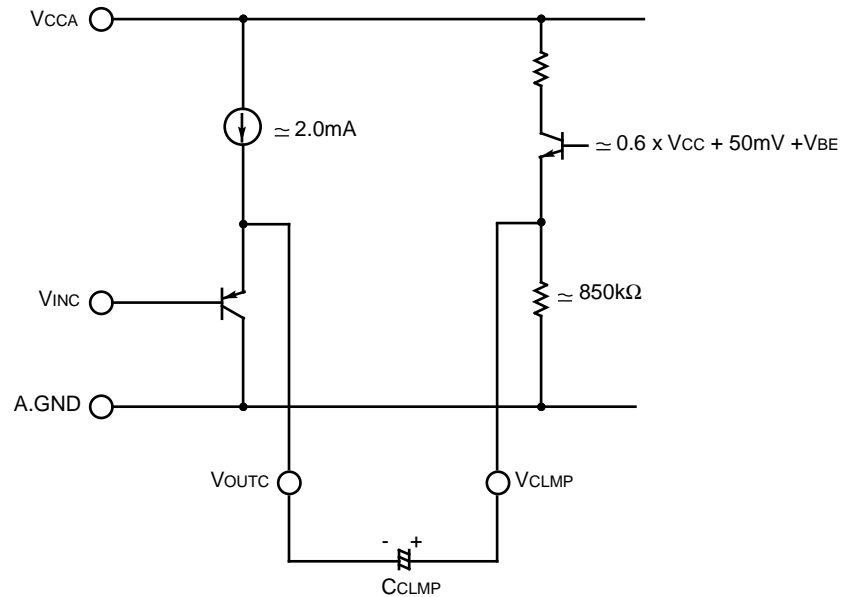
CLK = "H":  $\infty$

VRB: This is the voltage on VRB Pin, not VRB Pin itself.

IBIAS: Constant input bias current

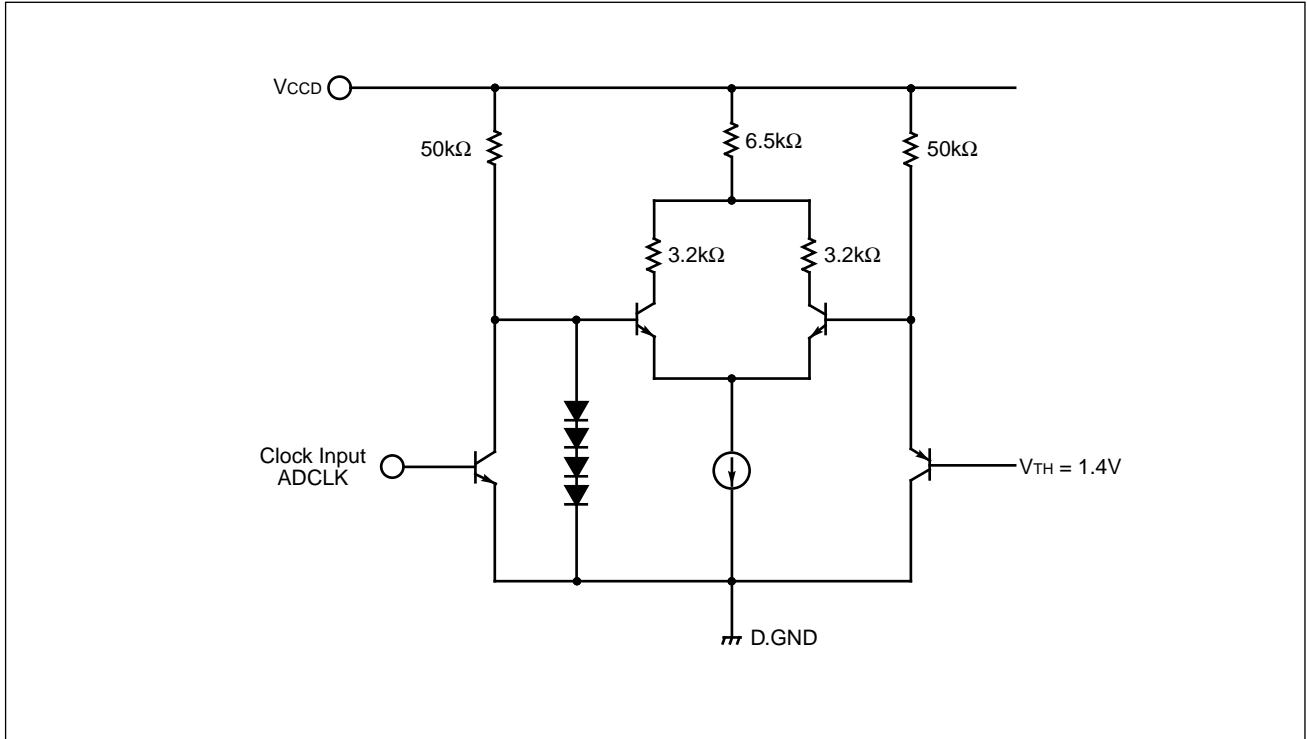
Vd: Base-Collector junction diode of emitter follower transistor

### • Clamp Input Equivalent Circuit

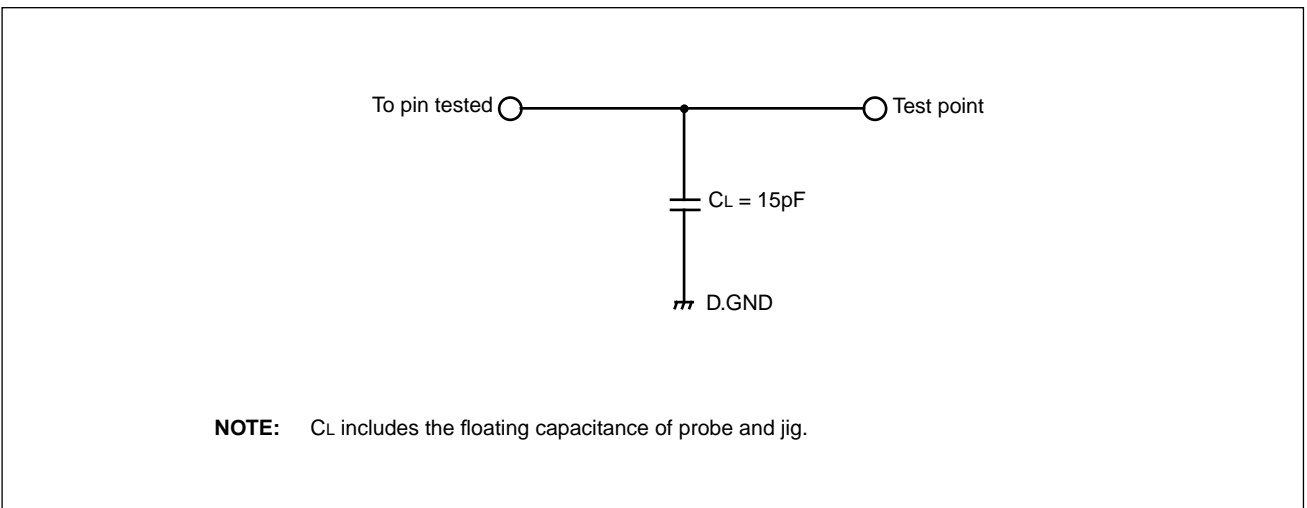


# MB40168/MB40178

## • Digital Input Equivalent Circuit



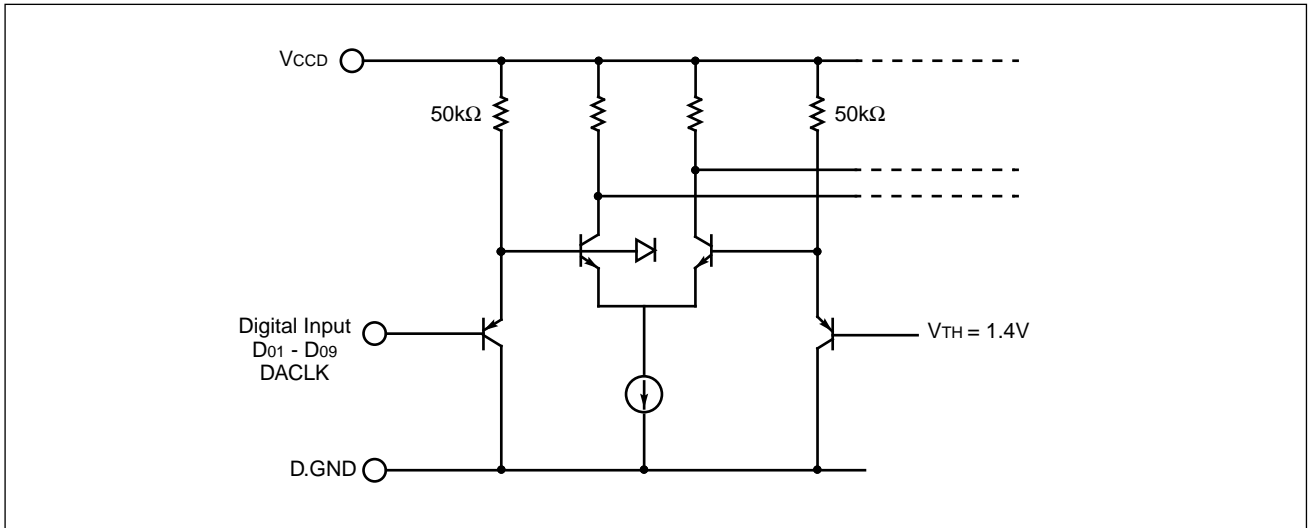
## • Digital Output Load Circuit



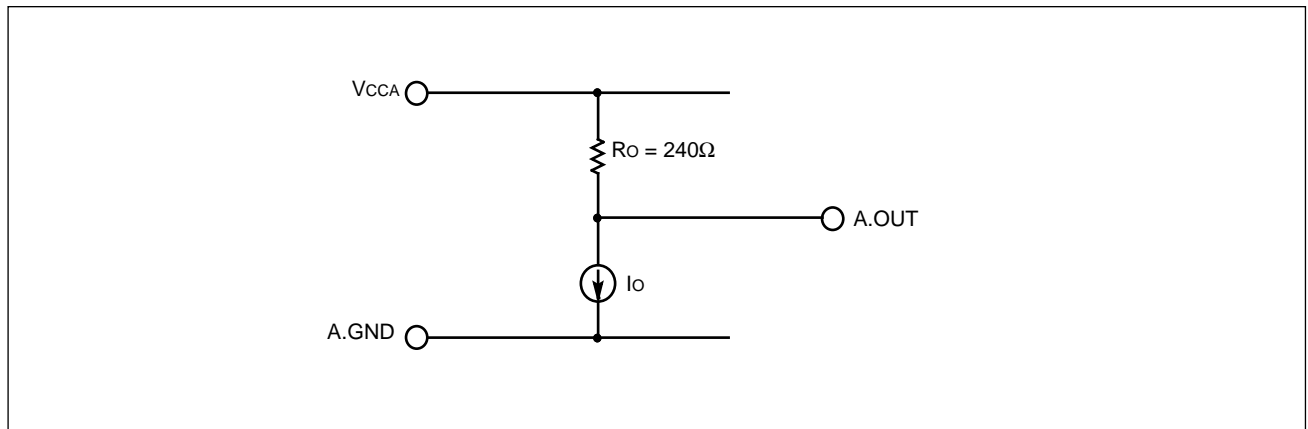
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## ■ EQUIVALENT CIRCUITS OF DAC BLOCK

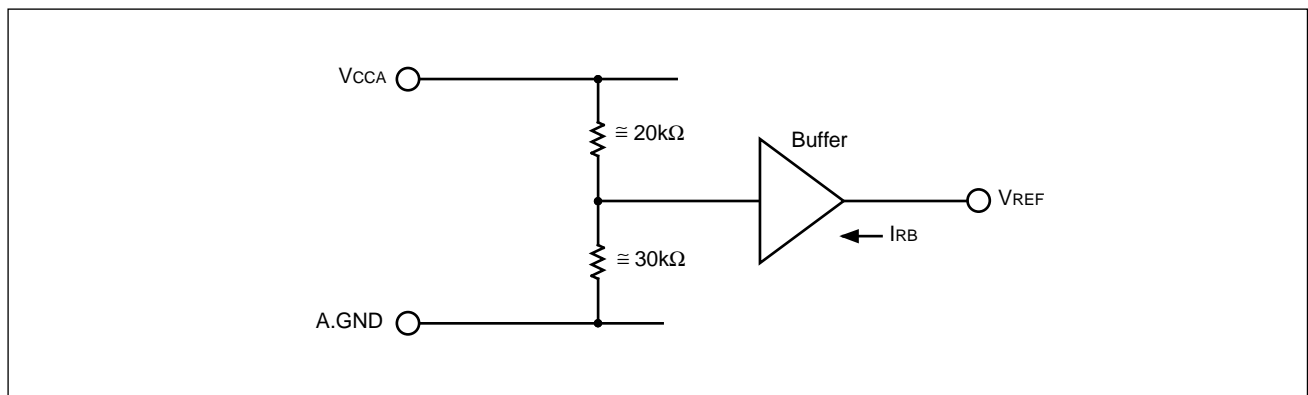
### • Digital Input Equivalent Circuit



### • Analog Output Equivalent Circuit



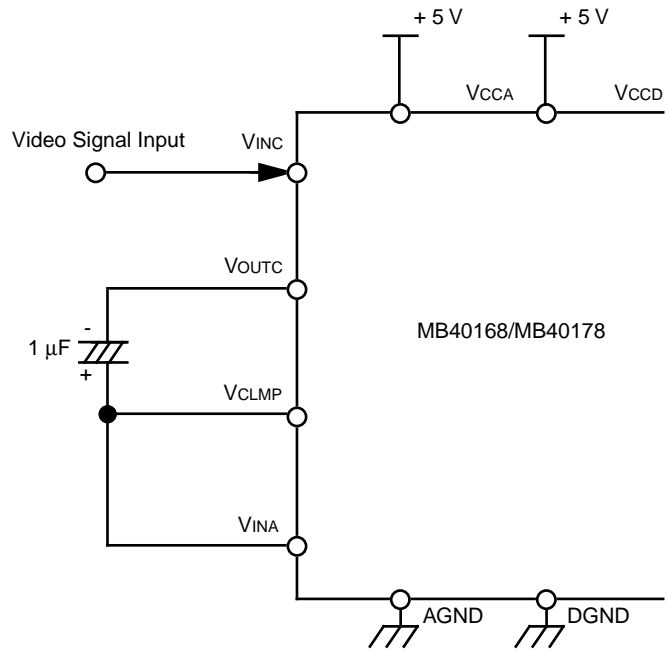
### • Reference Voltage Generator Equivalent Circuit



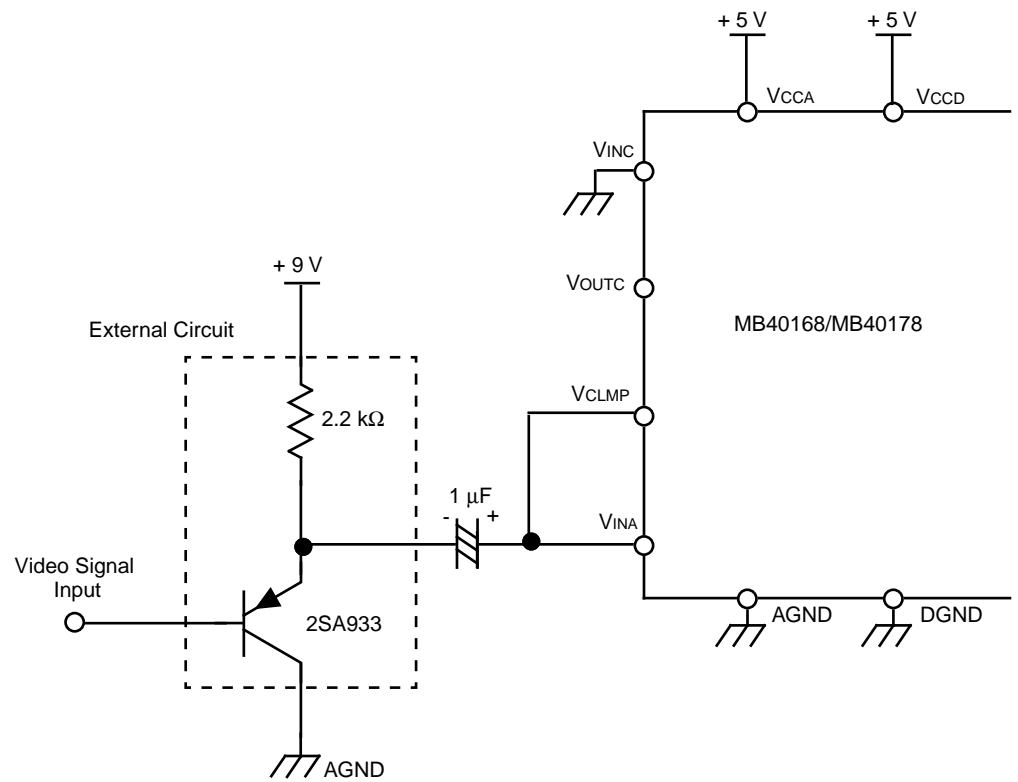
# MB40168/MB40178

## ■ TYPICAL CONNECTION CIRCUITS

Example 1: Video Signal Input to VINC Pin

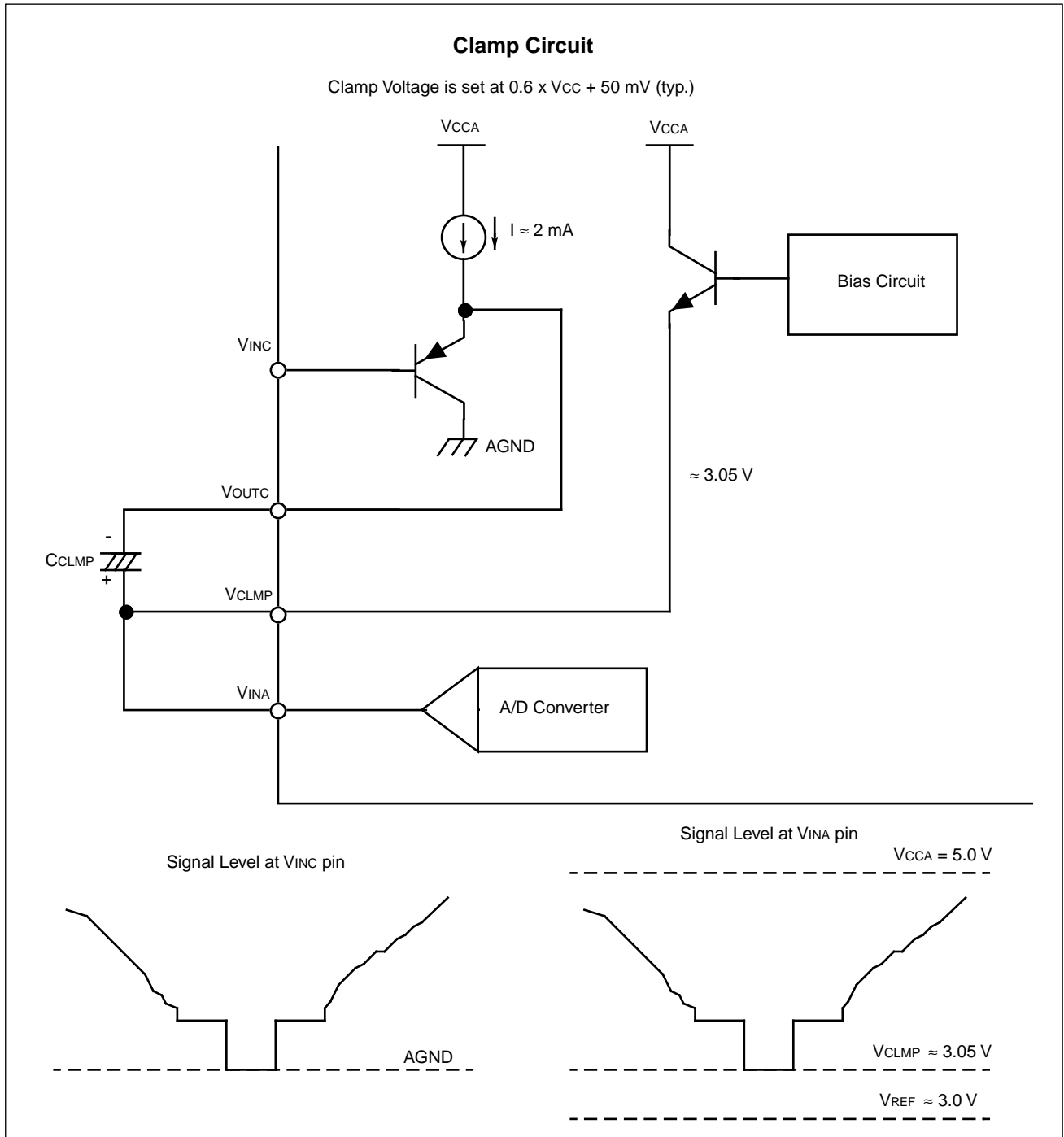


Example 2: Video Signal Input to VCLMP and VINA Pins



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## CLAMP CIRCUIT OPERATION



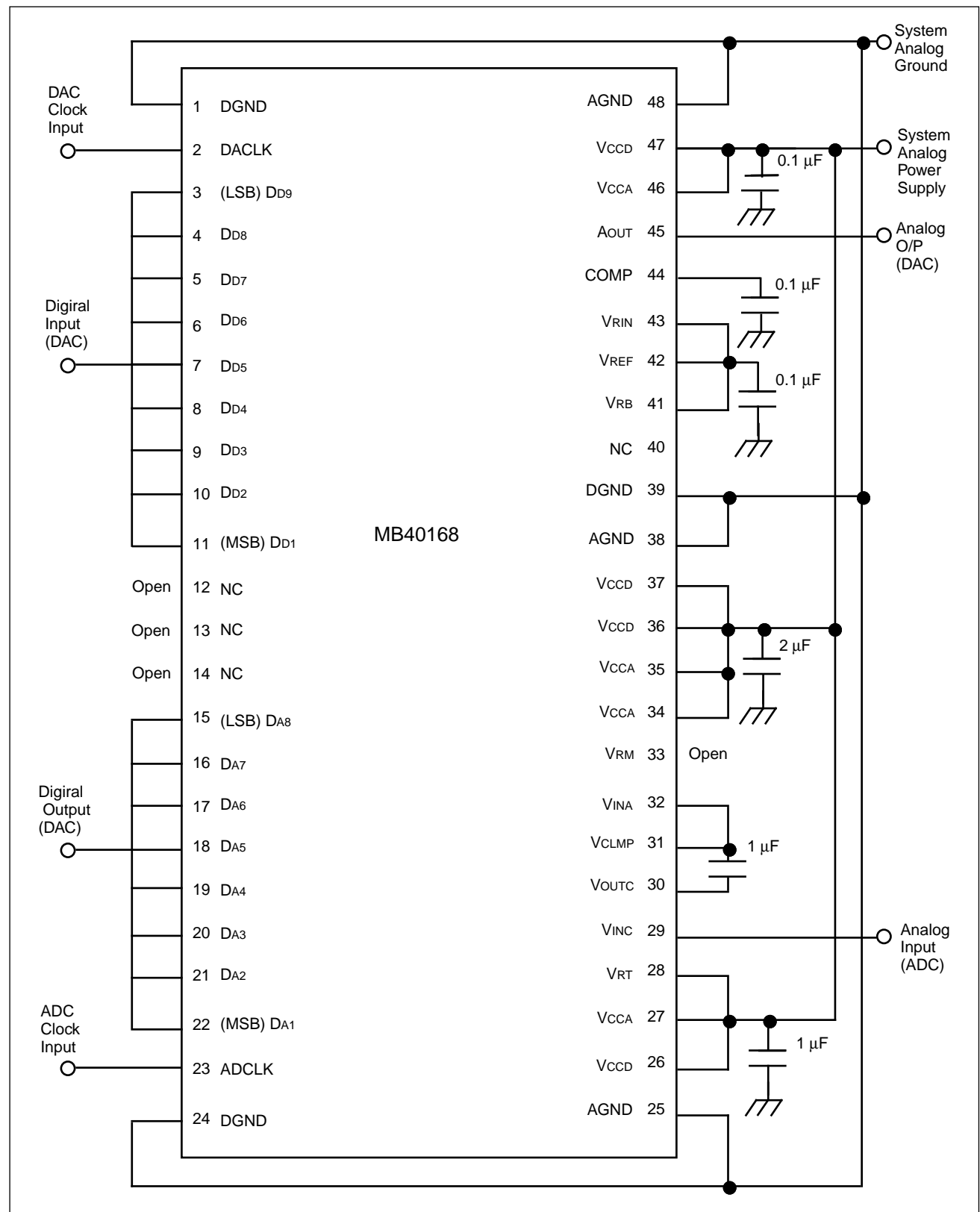
**Note:** When Clamp Circuit is not applied the signals should be connected as follows:

VINC: Connect to GND.  
 VOUTC: Leave open.  
 VCLMP: Leave open.



# MB40168/MB40178

## ■ TYPICAL CONNECTION CIRCUIT(Example)



# MB40168/MB40178

## ■ NOTES ON PCB LAYOUT

### Power Supply Lines

The device's power supply lines ( $V_{CCA}$ ,  $V_{CCD}$ , AGND and DGND) should be laid out as analog lines and should be separated in so far as possible from other digital lines in order to reduce noise. Also the track widths of these lines should be as wide as possible to reduce parasitic impedance.

### Coupling Capacitors

The device's power supply lines  $V_{CCA}$  and  $V_{CCD}$  and the reference voltage pins  $V_{RIN}$ ,  $V_{REF}$ ,  $V_{RB}$ , and  $V_{RT}$  should be decoupled to analog ground by means of approx. 1  $\mu$ F capacitors which should be placed as close as possible to these pins.

### Digital Output Load

The load at the digital outputs should be kept as low as possible to prevent noise in the power supply lines caused by digital output switching. If, due to long wiring, the load becomes large then a buffer with small input capacitance should be inserted to reduce load capacitance.

## ■ OTHER NOTES ON OPERATION

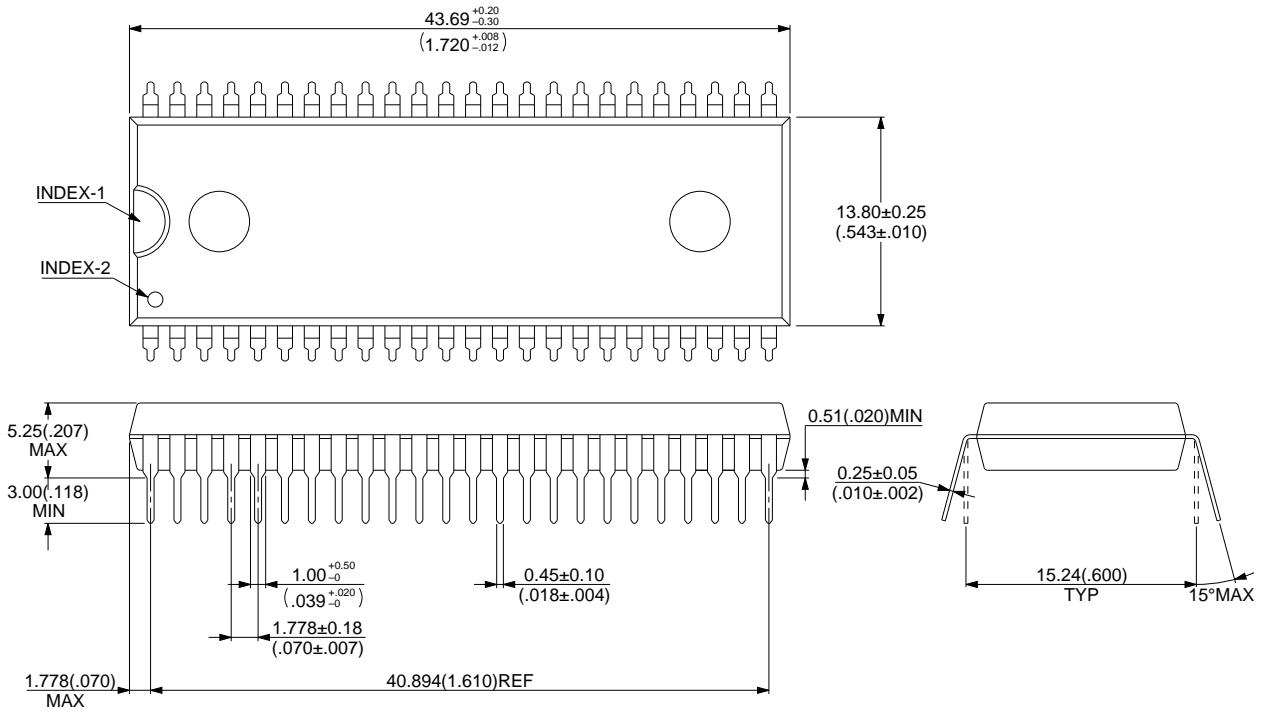
When using the D/A converter with its  $V_{RIN}$  pin connected to the  $V_{REF}$  pin, the A/D converter's  $V_{RB}$  pin must also be connected to the  $V_{REF}$  because otherwise the internal reference voltage generation circuitry cannot output 3 V.

When using the D/A converter with 8 bit resolution the DD9 (LSB) pin should be grounded.

# MB40168/MB40178

## ■ PACKAGE DIMENSIONS

48 pin, Plastic SH-DIP  
(DIP-48P-M01)



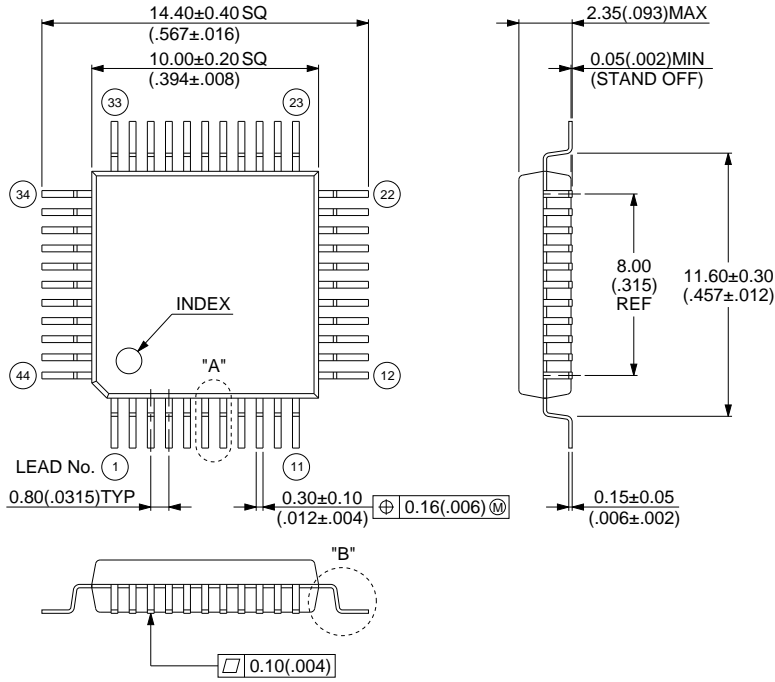
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Dimensions in mm (inches).

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44 pin, Plastic QFP  
(FPT-44P-M11)



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Dimensions in mm (inch).

# MB40168/MB40178

## FUJITSU LIMITED

*For further information please contact:*

### **Japan**

FUJITSU LIMITED  
Corporate Global Business Support Division  
Electronic Devices  
KAWASAKI PLANT, 4-1-1, Kamikodanaka  
Nakahara-ku, Kawasaki-shi  
Kanagawa 211-88, Japan  
Tel: (044) 754-3753  
Fax: (044) 754-3329

### **North and South America**

FUJITSU MICROELECTRONICS, INC.  
Semiconductor Division  
3545 North First Street  
San Jose, CA 95134-1804, U.S.A.  
Tel: (408) 922-9000  
Fax: (408) 432-9044/9045

### **Europe**

FUJITSU MIKROELEKTRONIK GmbH  
Am Siebenstein 6-10  
63303 Dreieich-Buchsschlag  
Germany  
Tel: (06103) 690-0  
Fax: (06103) 690-122

### **Asia Pacific**

FUJITSU MICROELECTRONICS ASIA PTE. LIMITED  
#05-08, 151 Lorong Chuan  
New Tech Park  
Singapore 556741  
Tel: (65) 281 0770  
Fax: (65) 281 0220

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