

8-bit 120MSPS Flash A/D Converter

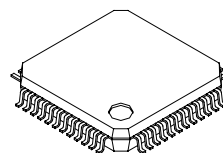
Description

The CXA3246Q is an 8-bit high-speed flash A/D converter capable of digitizing analog signals at the maximum rate of 120MSPS. ECL, PECL or TTL can be selected as the digital input level in accordance with the application. The TTL digital output level allows 1:2 demultiplexed output.

Features

- Differential linearity error: $\pm 0.5\text{LSB}$ or less
- Integral linearity error: $\pm 0.5\text{LSB}$ or less
- High-speed operation with a maximum conversion rate of 120MSPS
- Low input capacitance: 10pF
- Wide analog input bandwidth: 250MHz
- Low power consumption: 500mW
- 1:2 demultiplexed output
- 1/2 frequency-divided clock output (with reset function)
- Compatible with ECL, PECL and TTL digital input levels
- TTL output "H" levels: 2.8V (Typ.)
- +3.3V line CMOS IC direct connecting available
- Single +5V power supply operation available
- Surface mounting package (48-pin QFP)

48 pin QFP (Plastic)



LEAD TREATMENT: PALLADIUM PLATING

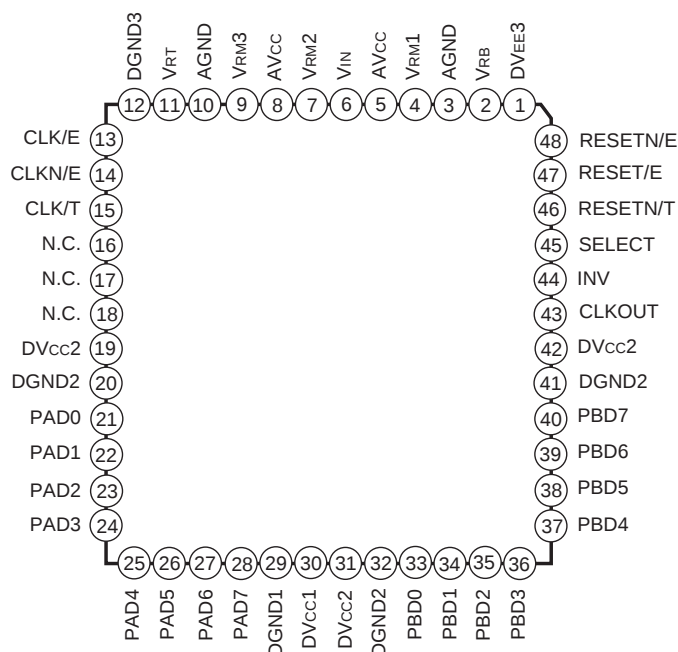
Structure

Bipolar silicon monolithic IC

Applications

- Magnetic recording (PRML)
- Communications (QPSK, QAM)
- LCDs
- Digital oscilloscopes

Pin Configuration (Top View)



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Absolute Maximum Ratings (Ta = 25°C)

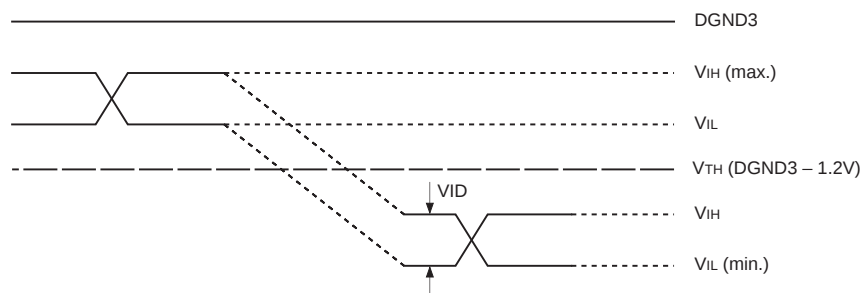
			Unit
• Supply voltage	AV _{CC} , DV _{CC} 1, DV _{CC} 2	−0.5 to +7.0	V
	DGND3	−0.5 to +7.0	V
	DV _{EE} 3	−7.0 to +0.5	V
	DGND3 − DV _{EE} 3	−0.5 to +7.0	V
• Analog input voltage	V _{IN}	V _{RT} − 2.7 to AV _{CC}	V
• Reference input voltage	V _{RT}	2.7 to AV _{CC}	V
	V _{RB}	V _{IN} − 2.7 to AV _{CC}	V
	V _{RT} − V _{RB}	2.5	V
• Digital input voltage	ECL/PECL input pin	DV _{EE} 3 − 0.5 to DGND3 + 0.5	V
	TTL input pin	DGND1 − 0.5 to DV _{CC} 1 + 0.5	V
	VID*1 (***/E − ***N/E)	2.7	V
• Storage temperature	T _{stg}	−65 to +150	°C
• Allowable power dissipation	P _D	1.6	W

(when mounted on a two-layer glass fabric base epoxy board with dimensions of 50mm × 50mm, 1.6mm thick)

Recommended Operating Conditions

		With a single power supply			With dual power supply			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
• Supply voltage	DV _{CC} 1, DV _{CC} 2, AV _{CC}	+4.75	+5.0	+5.25	+4.75	+5.0	+5.25	V
	DGND1, DGND2, AGND	−0.05	0	+0.05	−0.05	0	+0.05	V
	DGND3	+4.75	+5.0	+5.25	−0.05	0	+0.05	V
	DV _{EE} 3	−0.05	0	+0.05	−5.5	−5.0	−4.75	V
• Analog input voltage	V _{IN}	V _{RB}		V _{RT}	V _{RB}		V _{RT}	V
• Reference input voltage	V _{RT}	+2.9		+4.1	+2.9		+4.1	V
	V _{RB}	+1.4		+2.6	+1.4		+2.6	V
	V _{RT} − V _{RB}	1.5		2.1	1.5		2.1	V
• Digital input voltage	ECL/PECL input pin	: V _{IH} DV _{EE} 3 + 1.5		DGND3 DV _{EE} 3 + 1.5	DGND3		DGND3	V
		: V _{IL} DV _{EE} 3 + 1.1		V _{IH} − 0.4 DV _{EE} 3 + 1.1	V _{IH} − 0.4		V _{IH} − 0.4	V
	TTL input pin	: V _{IH} 2.0		2.0	2.0			V
		: V _{IL}		0.8			0.8	V
	VID*1 (***/E − ***N/E)	0.4	0.8		0.4	0.8		V
• Maximum conversion rate	F _c (Straight mode)	100			100			MSPS
	(DMUX mode)	120			120			MSPS
• Ambient temperature	T _a	−20		+75	−20		+75	°C

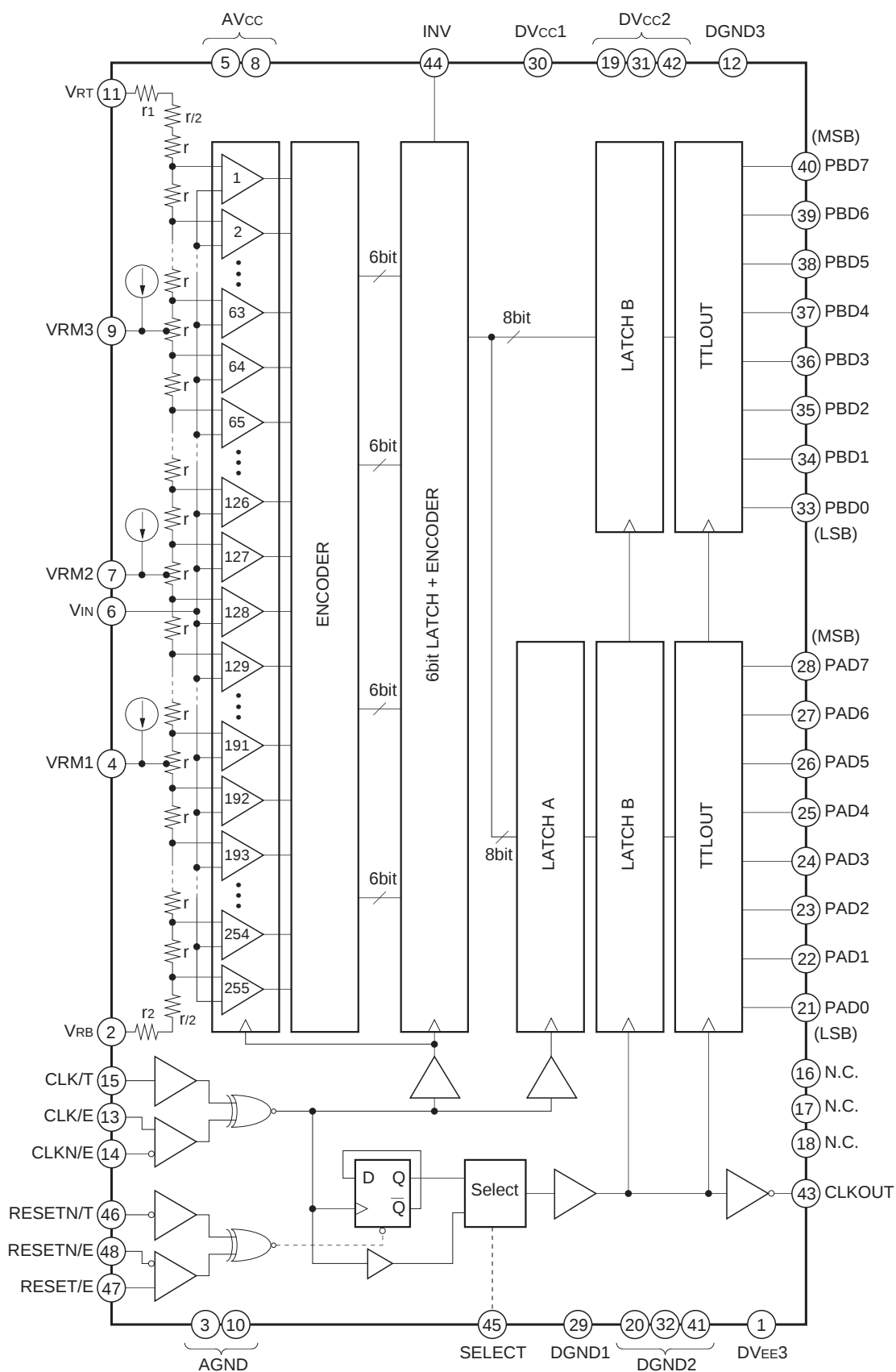
*1 VID: Input Voltage Differential

ECL and PECL switching level

Pin Description

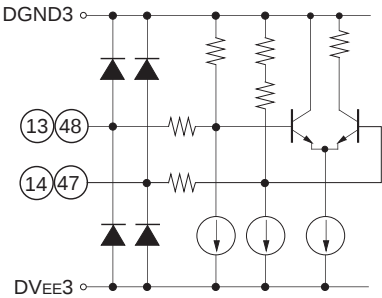
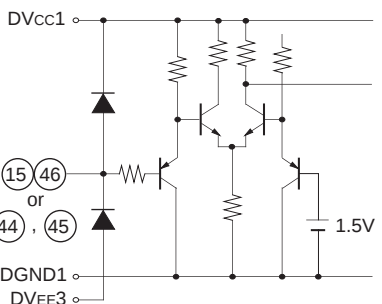
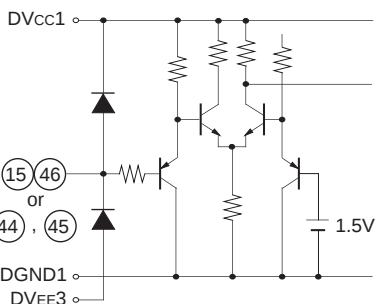
[Symbol]	[Pin No.]	[Description]	[Typical voltage level with a single power supply]	[Typical voltage level with dual power supply]
DVEE3	1	Digital power supply	0V	−5.0V
VRB	2	Bottom reference voltage	1.4 to 2.6V	1.4 to 2.6V
AGND	3	Analog ground	0V	0V
VRM1	4	Reference voltage mid point	—	—
AVCC	5	Analog power supply	+5V	+5V
VIN	6	Analog signal input	VRB to VRT	VRB to VRT
VRM2	7	Reference voltage mid point	—	—
AVCC	8	Analog power supply	+5V	+5V
VRM3	9	Reference voltage mid point	—	—
AGND	10	Analog ground	0V	0V
VRT	11	Reference voltage (typ.)	2.9 to 4.1V	2.9 to 4.1V
DGND3	12	Digital power supply	+5V	0V
CLK/E	13	ECL/PECL clock input	PECL	ECL
CLKN/E	14	ECL/PECL clock input	PECL	ECL
CLK/T	15	TTL clock input	TTL	TTL
N.C.	16 to 18	No connected pin	—	—
DVcc2	19	Digital power supply	+5V	+5V
DGND2	20	Digital ground	0V	0V
PAD0 to PAD7	21 to 28	PA side data output	TTL	TTL
DGND1	29	Digital ground	0V	0V
DVcc1	30	Digital power supply	+5V	+5V
DVcc2	31	Digital power supply	+5V	+5V
DGND2	32	Digital ground	0V	0V
PBD0 to PBD7	33 to 40	PB side data output	TTL	TTL
DGND2	41	Digital ground	0V	0V
DVcc2	42	Digital power supply	+5V	+5V
CLKOUT	43	Clock output	TTL	TTL
INV	44	Data output polarity inversion	TTL	TTL
SELECT	45	Output mode selection	TTL	TTL
RESETN/T	46	TTL reset input	TTL	TTL
RESET/E	47	ECL/PECL reset input	PECL	ECL
RESETN/E	48	ECL/PECL reset input	PECL	ECL

Block Diagram



Pin Description and I/O Pin Equivalent Circuit

Pin No.	Symbol	I/O	Standard voltage level	Equivalent circuit	Description
3, 10	AGND		GND		Analog ground. Separated from the digital ground.
5, 8	AV _{CC}		+5V (typ.)		Analog power supply. Separated from the digital power supply.
20, 29 32, 41	DGND1 DGND2		GND		Digital ground.
19, 30 31, 42	DV _{CC} 1 DV _{CC} 2		+5V (typ.)		Digital power supply.
12	DGND3		+5V (typ.) (With a single power supply) ----- GND (With dual power supply)		Digital power supply. Ground for ECL input. +5V for PECL and TTL inputs.
1	DV _{EE} 3		GND (With a single power supply) ----- –5V (typ.) (With dual power supply)		Digital power supply. –5V for ECL input. Ground for PECL and TTL inputs.
16, 17 18	N.C.				No connected pin. Not connected with the internal circuits.

Pin No.	Symbol	I/O	Standard voltage level	Equivalent circuit	Description
13	CLK/E	I	ECL/PECL		Clock input.
14	CLKN/E	I			CLK/E complementary input. When left open, this pin goes to the threshold voltage. Only CLK/E can be used for operation, but complementary inputs are recommended to attain fast and stable operation.
48	RESETN/E	I			Reset signal input. When set to low level, the built-in CLK frequency divider circuit can be reset.
47	RESET/E	I			RESETN/E complementary input. When left open, this pin goes to the threshold voltage. Only RESETN/E can be used for operation.
15	CLK/T	I	TTL		Clock input.
46	RESETN/T	I			Reset signal input. When left open, this pin goes to high level. When set to low level, the built-in CLK frequency divider circuit can be reset.
44	INV	I	TTL		Data output polarity inversion input. When left open, this input goes to high level. (See Table 1. I/O Correspondence Table.)
45	SELECT		Vcc or GND		Data output mode selection. (See Table 2. Operation Mode Table.)

Pin No.	Symbol	I/O	Standard voltage level	Equivalent circuit	Description
11	V_{RT}	I	4.0V (typ.)		Top reference voltage. By-pass to AGND with a 1μF tantal capacitor and a 0.1μF chip capacitor.
9	V_{RM3}		$V_{RB} + \frac{3}{4}(V_{RT} - V_{RB})$		Reference voltage mid point. By-pass to AGND with a 0.1μF chip capacitor.
7	V_{RM2}		$V_{RB} + \frac{2}{4}(V_{RT} - V_{RB})$		Reference voltage mid point. By-pass to AGND with a 0.1μF chip capacitor.
4	V_{RM1}		$V_{RB} + \frac{1}{4}(V_{RT} - V_{RB})$		Reference voltage mid point. By-pass to AGND with a 0.1μF chip capacitor.
2	V_{RB}	I	2.0V (typ.)		Bottom reference voltage. By-pass to AGND with a 1μF tantal capacitor and a 0.1μF chip capacitor.
6	V_{IN}	I	V_{RT} to V_{RB}		Analog input.
21 to 28	PAD0 to PAD7	O	TTL		Port A side data output. TTL output; the high level is clamped to approximately 2.8V.
33 to 40	PBD0 to PBD7	O			Port B side data output. TTL output; the high level is clamped to approximately 2.8V.
43	CLKOUT	O			Clock output. (See Table 2. Operation Mode Table.) TTL output; the high level is clamped to approximately 2.8V.

Electrical Characteristics

(AV_{CC}, DV_{CC}1, 2, DGND3 = +5V, AGND, DGND1, 2, DV_{EE}3 = 0V, V_{RT} = 4V, V_{RB} = 2V, Ta = 25°C)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Resolution				8		bits
DC characteristics						
Integral linearity error	E _{IL}	V _{IN} = 2Vp-p, Fc = 5MSPS			±0.5	LSB
Differential linearity error	E _{DL}				±0.5	LSB
Analog input						
Analog input capacitance	C _{IN}	V _{IN} = +3.0V + 0.07V _{rms}		10		pF
Analog input resistance	R _{IN}		7	20	40	kΩ
Analog input current	I _{IN}		0	100	285	μA
Reference input						
Reference resistance	R _{ref} *2		400	600	740	Ω
Reference current	I _{ref} *3		2.7	3.3	5.0	mA
Offset voltage V _{RT} side	E _{OT}		6	8	10	mV
Offset voltage V _{RB} side	E _{OB}		0	1.5	3	mV
Digital input (ECL, PECL)						
Digital input voltage: High	V _{IH}	V _{IH} = DGND3 – 0.8V V _{IL} = DGND3 – 1.6V	DV _{EE} 3 + 1.5	DGND3 – 1.2	DGND3	V
: Low	V _{IL}		DV _{EE} 3 + 1.1		V _{IH} – 0.4	V
Threshold voltage	V _{TH}					V
Digital input current: High	I _{IH}		–50		20	μA
: Low	I _{IL}		–50		20	μA
Digital input capacitance					5	pF
Digital input (TTL)						
Digital input voltage: High	V _{IH}	V _{IH} = 3.5V V _{IL} = 0.2V	2.0	1.5	0.8	V
: Low	V _{IL}					V
Threshold voltage	V _{TH}					V
Digital input current: High	I _{IH}		–10		5	μA
: Low	I _{IL}		–20		0	μA
Digital input capacitance					5	pF
Digital output (TTL)						
Digital output voltage: High	V _{OH}	I _{OH} = –2mA	2.4		0.5	V
: Low	V _{OL}	I _{OL} = 1mA				V
Switching characteristics						
Maximum conversion rate	Fc	DMUX mode	120			MSPS
Aperture jitter	T _{aj}			10		ps
Sampling delay	T _{ds}		1.2	1.4	1.6	ns
Clock high pulse width	T _{pw1}	CLK	3.0			ns
Clock low pulse width	T _{pw0}	CLK	4.5			ns
Reset signal setup time	T _{rs}	RESETN – CLK	1.0			ns
Reset signal hold time	T _{rh}	RESETN – CLK	–0.5			ns
Clock output delay	T _{d_clk}	(C _L = 5pF)	3.0	4.5	7.0	ns
Data output delay	T _{do1}	DMUX mode (C _L = 5pF)		T*4 + 0.5		ns
	T _{do2}	(C _L = 5pF)	3.5	5.0	7.5	ns
Output rise time	T _r	0.8 to 2.0V (C _L = 5pF)		1		ns
Output fall time	T _f	0.8 to 2.0V (C _L = 5pF)		1		ns

* These characteristics are for PECL input unless otherwise specified.

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Dynamic characteristics						
Input bandwidth		$V_{IN} = 2V_{p-p}, -3dB$	250			MHz
S/N ratio		$\left\{ \begin{array}{l} F_c = 120MSPS, \\ fin = 1kHz \text{ } F_s \\ DMUX \text{ mode} \end{array} \right.$		46		dB
		$\left\{ \begin{array}{l} F_c = 120MSPS, \\ fin = 29.999MHz \text{ } F_s \\ DMUX \text{ mode} \end{array} \right.$		42		dB
Error rate		$\left\{ \begin{array}{l} F_c = 120MSPS, \\ fin = 1kHz \text{ } F_s \\ DMUX \text{ mode} \\ Error > 16LSB \end{array} \right.$			10^{-12}	TPS* ⁵
		$\left\{ \begin{array}{l} F_c = 120MSPS, \\ fin = 29.999MHz \text{ } F_s \\ DMUX \text{ mode} \\ Error > 16LSB \end{array} \right.$			10^{-9}	TPS
		$\left\{ \begin{array}{l} F_c = 100MSPS, \\ fin = 24.999MHz \text{ } F_s \\ Straight \text{ mode} \\ Error > 16LSB \end{array} \right.$			10^{-9}	TPS
Power supply						
Supply current	$I_{CC} + I_{EE}$		70	98	140	mA
AVcc Pin supply current	I_{AVCC}		45		87	mA
DVcc1 pin supply current	I_{DVCC1}		20		36	mA
DVcc2 pin supply current	I_{DVCC2}		5		15	mA
DGND3 pin supply current	I_{DGND3}		0.5		1.5	mA
Power consumption	P_d * ⁶		400	500	700	mW

*2 Rref: Resistance value between V_{RT} and V_{RB}

$$*3 \text{ } I_{ref} = \frac{V_{RT} - V_{RB}}{R_{ref}}$$

$$*4 \text{ } T = \frac{1}{F_c}$$

*5 TPS: Times Per Sample

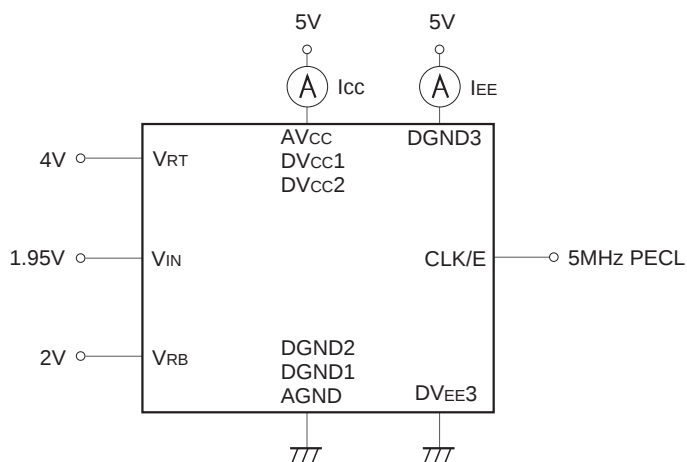
$$*6 \text{ } P_d = (I_{CC} + I_{EE}) \cdot V_{CC} + \frac{(V_{RT} - V_{RB})^2}{R_{ref}}$$

V _{IN}	Step	INV															
		1								0							
		D7				D0				D7				D0			
V _{RT}	255	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
	254	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1
V _{RM2}	⋮																
	128	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
	127	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
	⋮																
V _{RB}	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0
	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1

Table 1. I/O Correspondence Table

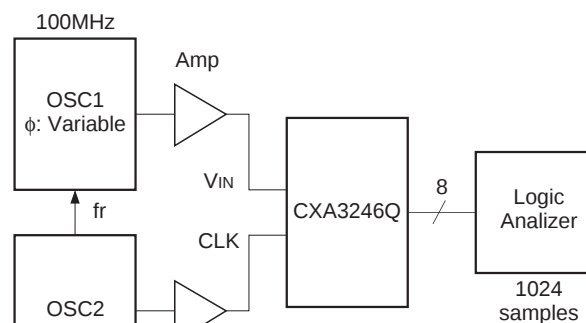
Electrical Characteristics Measurement Circuit

Current Consumption Measurement Circuit



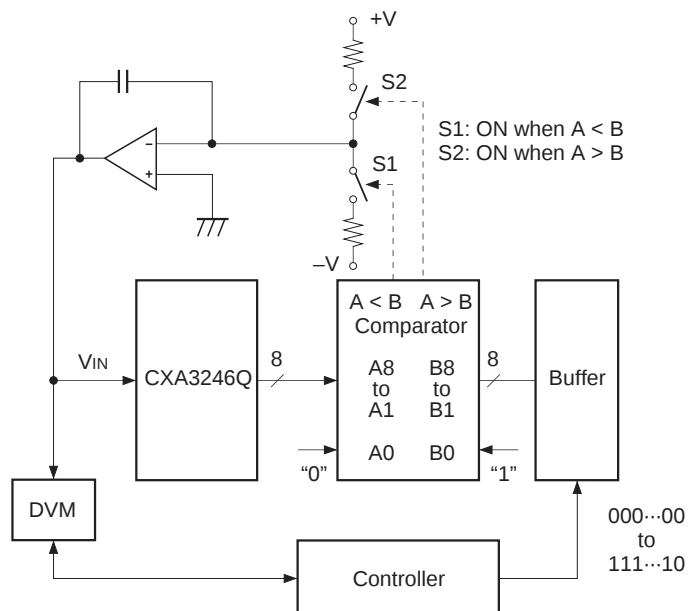
Sampling Delay Measurement Circuit

Aperture Jitter Measurement Circuit

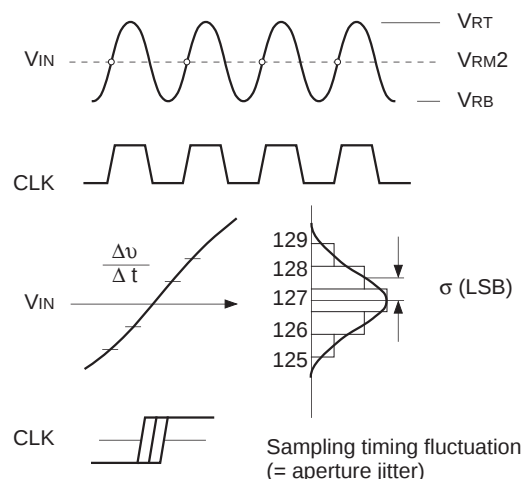


Integral Linearity Error Measurement Circuit

Differential Linearity Error Measurement Circuit



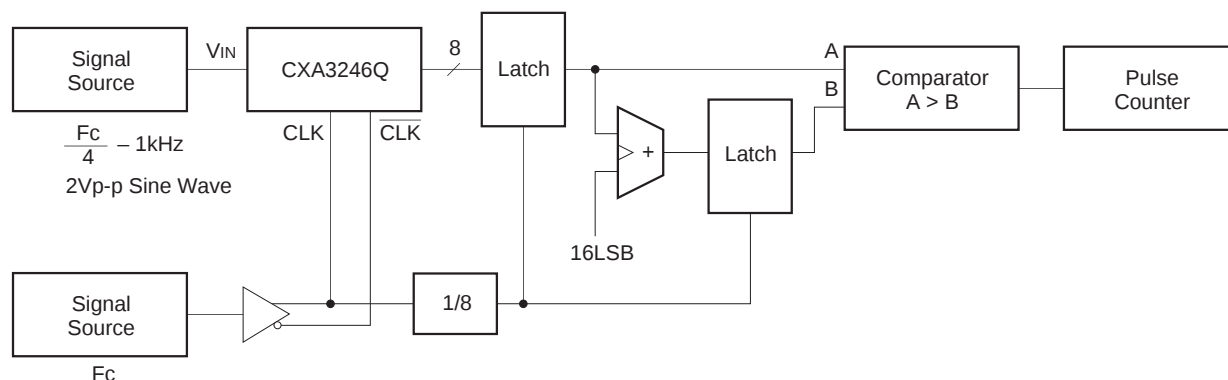
Aperture Jitter Measurement Method



Where σ (LSB) is the deviation of the output codes when the largest slew rate point is sampled at the clock which has exactly the same frequency as the analog input signal, the aperture jitter T_{aj} is:

$$T_{aj} = \sigma / \frac{\Delta v}{\Delta t} = \sigma / \left(-\frac{256}{2} \times 2\pi f \right)$$

Error Rate Measurement Circuit



Description of Operation Modes

The CXA3246Q has two types of operation modes which are selected with Pin 45 (SELECT).

Operation mode	SELECT pin	Maximum conversion rate	Data output	Clock output
DMUX mode	Vcc	120MSPS	Demultiplexed output 60Mbps	The input clock is 1/2 frequency divided and output. 60MHz
Straight mode	GND	100MSPS	Straight output 100Mbps	The input clock is inverted and output. 100MHz

Table 2. Operation Mode Table

1. DMUX mode (See Application Circuit 1-(1), (2) and (3).)

Set the SELECT pin to Vcc for this mode. In this mode, the clock frequency is divided by 2 in the IC, and the data is output after being demultiplexed by this 1/2 frequency-divided clock. The 1/2 frequency-divided clock, which has adequate setup time and hold time for the output data, is output from the clock output pin.

When using the multiple CXA3246Q in DMUX mode, the start timing of the 1/2 frequency-divided clocks becomes out of phase, producing operation such as that shown in the example on the next page. As a countermeasure, the CXA3246Q has a function that resets the 1/2 frequency-divided clocks.

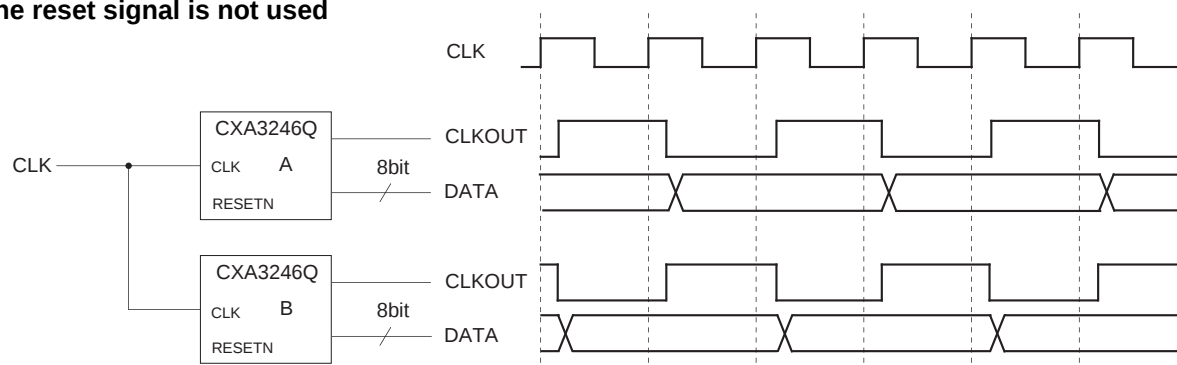
When resetting this 1/2 frequency-divided clock, the low level of the reset signal should be input to the RESETN pin (Pin 46 or 48). The reset signal requires the setup time ($T_{rs} \geq 1.0\text{ns}$) and hold time ($T_{rh} \geq -0.5\text{ns}$) to the clock rising edge because it is synchronized with and taken in the clock.

The reset period can be extended by making the low level period of the reset signal longer because the clock output pin is fixed to low (reset) during the low level period at the clock rising edge. If the reset start timing is regarded as not important, the timing where the reset signal is set from high to low is not so consequence. However, when the reset is released the timing where the reset signal is set from low to high must become significant because the timing is used to commence the 1/2 frequency-divided clock. In this case, the setup time (T_{rs}) is also necessary.

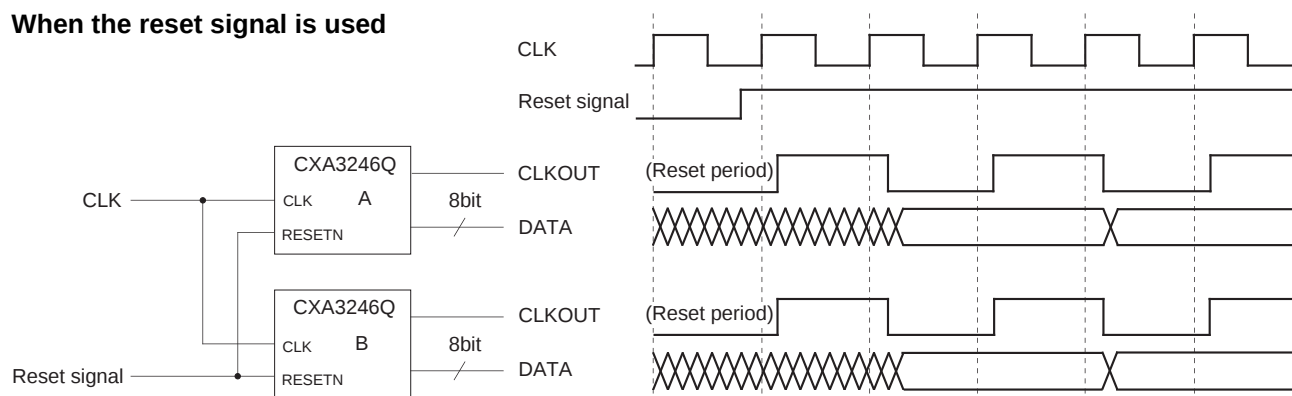
See the timing chart for detail. (This chart shows the example of reset for 2T.)

The A/D converter can operate at $F_c (\text{min.}) = 120\text{MSPS}$ in this mode.

When the reset signal is not used



When the reset signal is used



2. Straight mode (See Application Circuits 1-(4), (5) and (6).)

Set the SELECT pin to GND for this mode. In this mode, data output can be obtained in accordance with the clock frequency applied to the A/D converter for applications which use the clock applied to the A/D converter as the system clock.

The A/D converter can operate at $F_c (\text{min.}) = 100\text{MSPS}$ in this mode.

Digital input level and supply voltage settings

The logic input level for the CXA3246Q supports ECL, PECL and TTL levels.

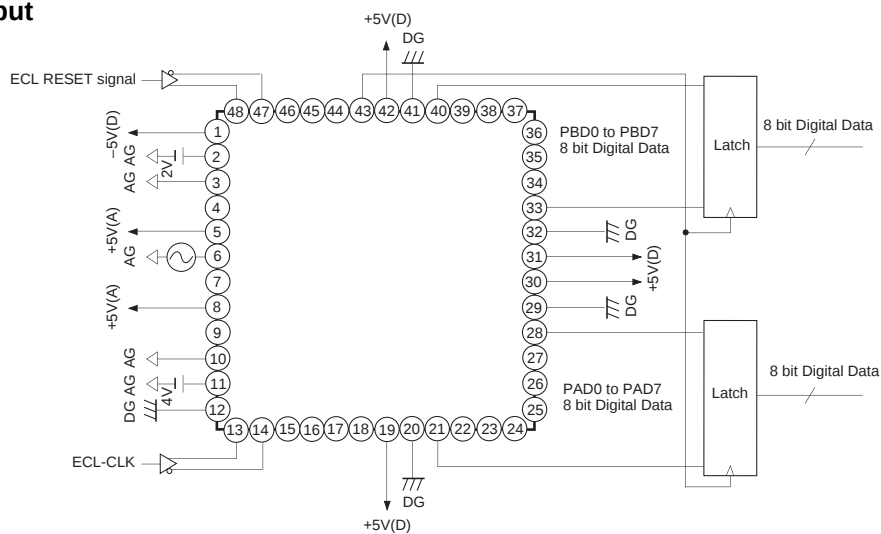
The power supplies (DV_{EE3}, DGND3) for the logic input block must be set to match the logic input (CLK and reset signals) level.

Digital input level	DV _{EE3}	DGND3	Supply voltage	Application circuits
ECL	−5V	0V	±5V	(1) (4)
PECL	0V	+5V	+5V	(2) (5)
TTL	0V	+5V	+5V	(3) (6)

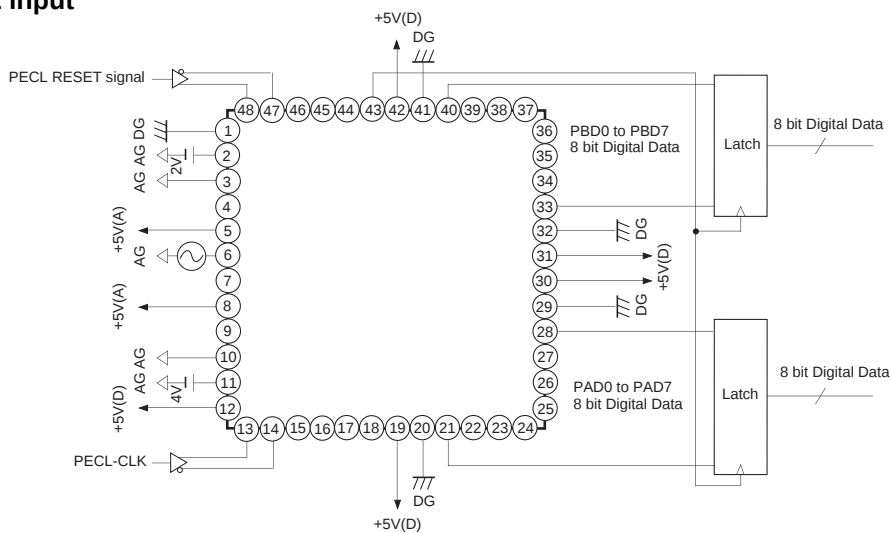
Table 3. Logic Input Level and Power Supply Settings

Application Circuit 1

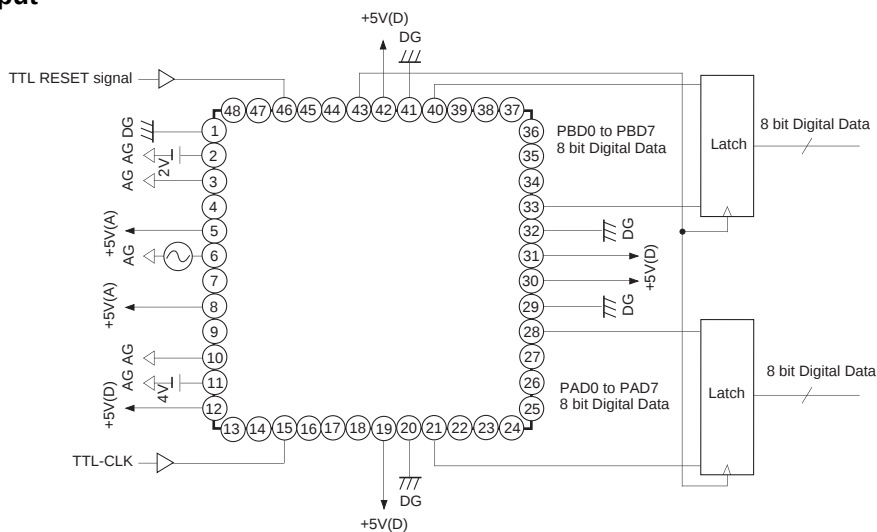
(1) DMUX ECL input

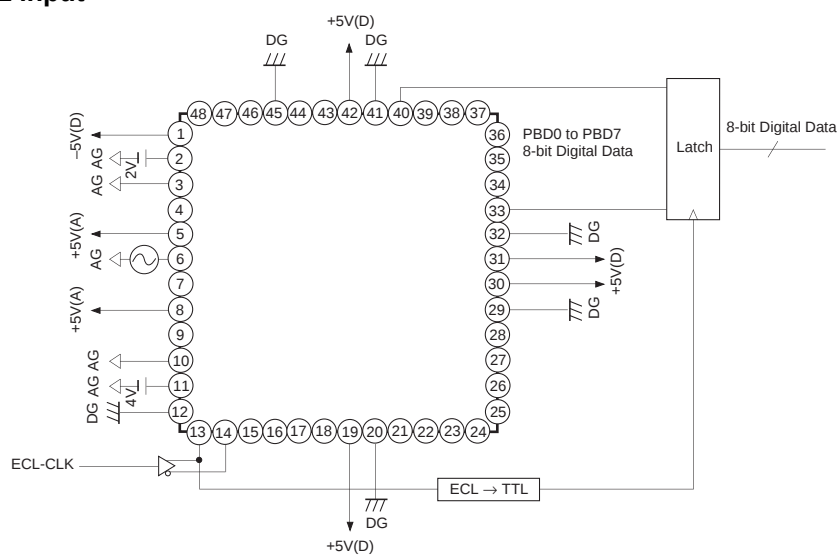
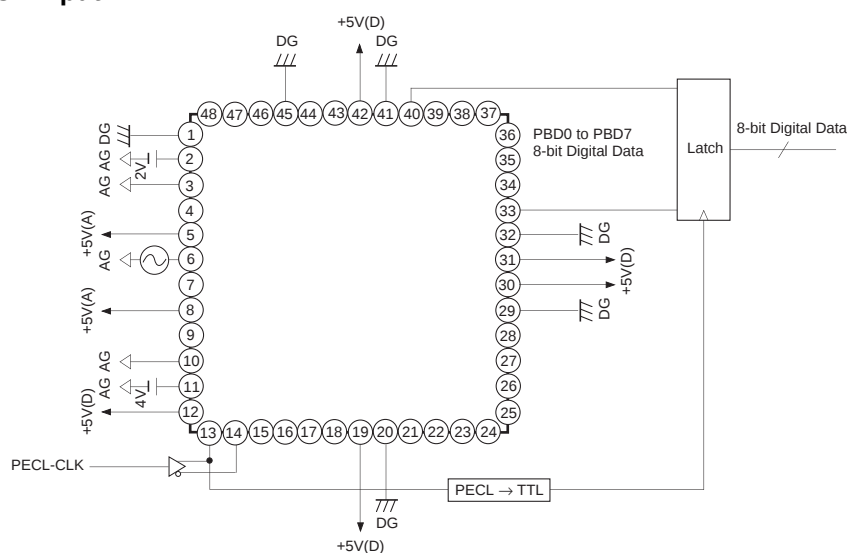
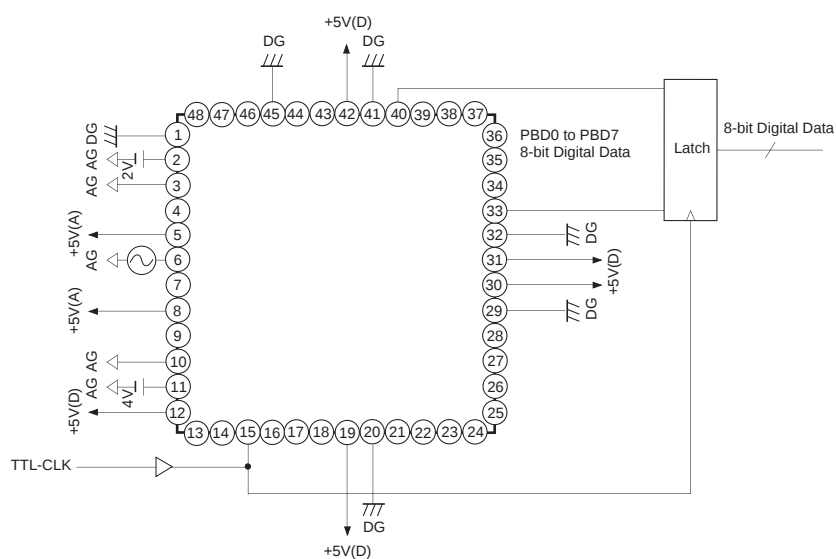


(2) DMUX PECL input

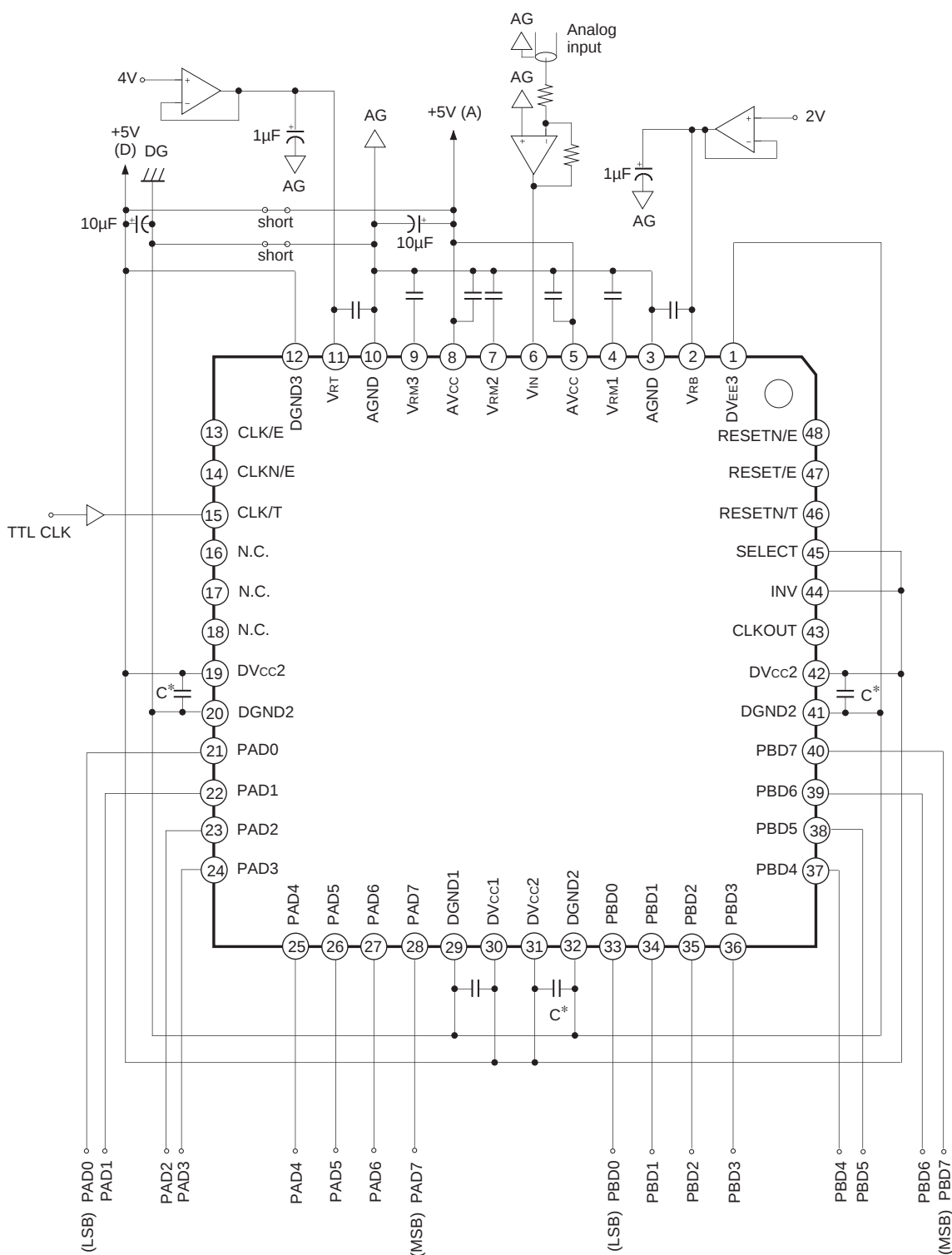


(3) DMUX TTL input



(4) Straight ECL input**(5) Straight PECL input****(6) Straight TTL input**

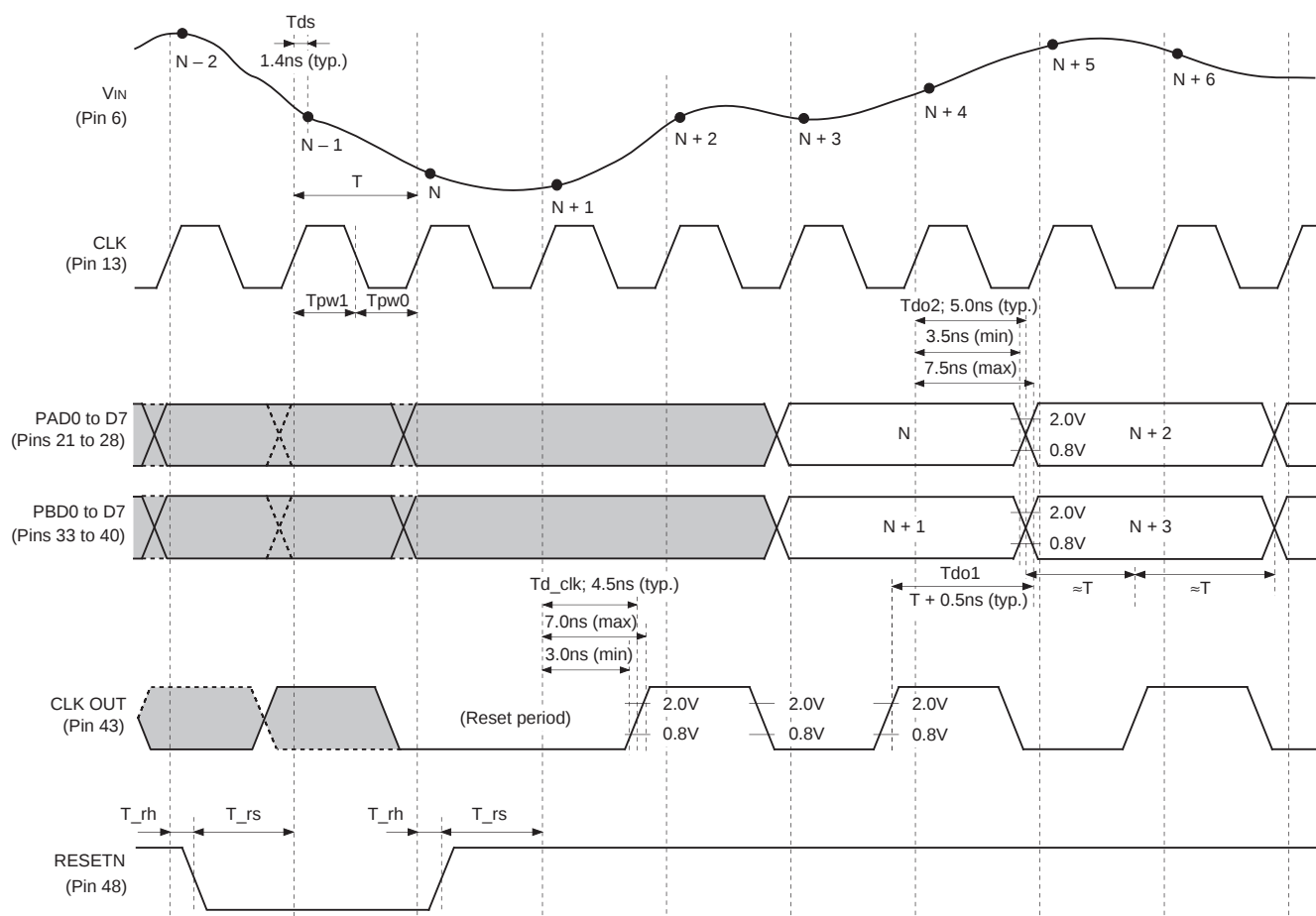
Application Circuit 2 DMUX Mode TTL I/O (When a single power supply is used)



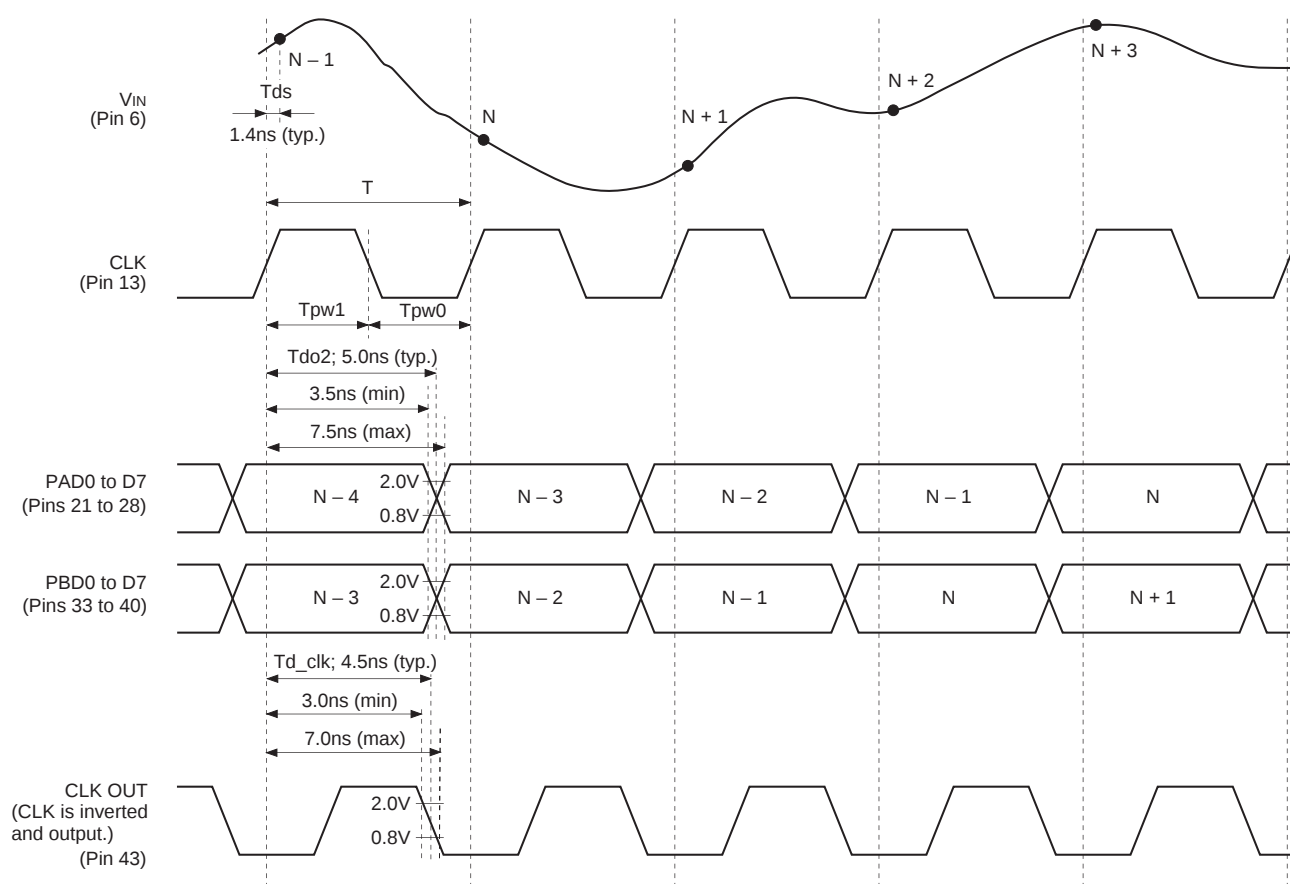
 Short the analog system and digital system at one point immediately under the A/D converter. See the Notes on Operation.
 is the chip capacitor of 0.1μF. Also, C* is important to suppress the noise generated during the TTL output circuit is operating. Place C* at the fixed position between the pins with the shortest distance.

Application circuits shown are typical examples illustrating the operation of the devices. Sony cannot assume responsibility for any problems arising out of the use of these circuits or for any infringement of third party patent and other right due to same.

DMUX Mode Timing Chart (Select = Vcc)



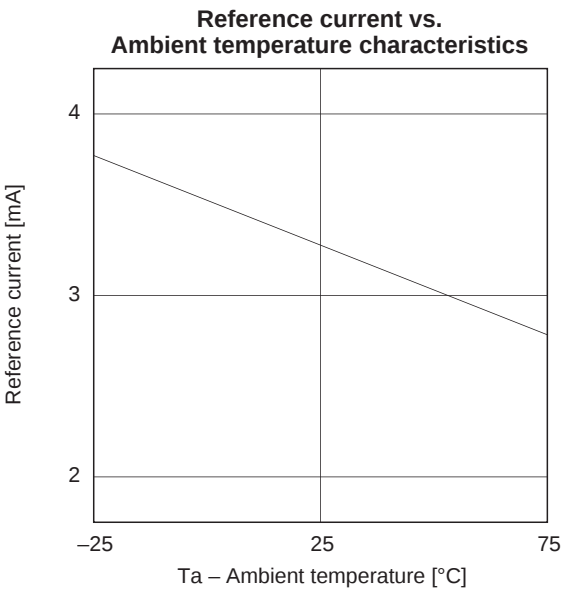
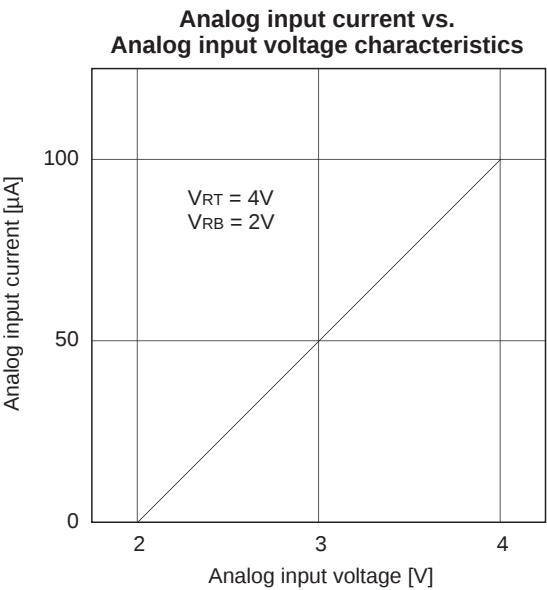
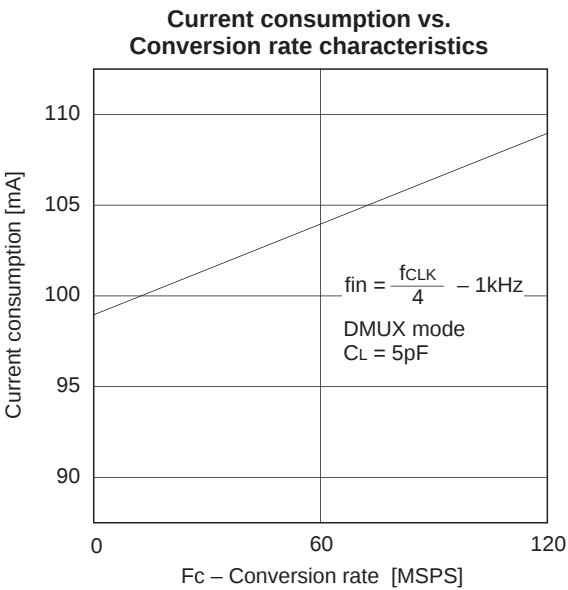
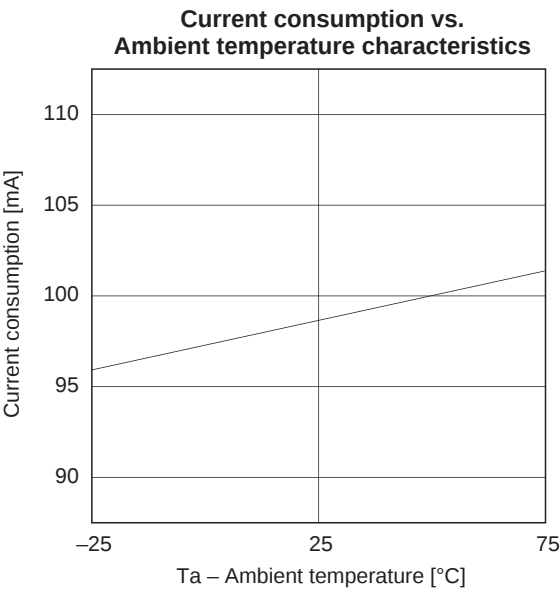
Straight Mode Timing Chart (Select = GND)

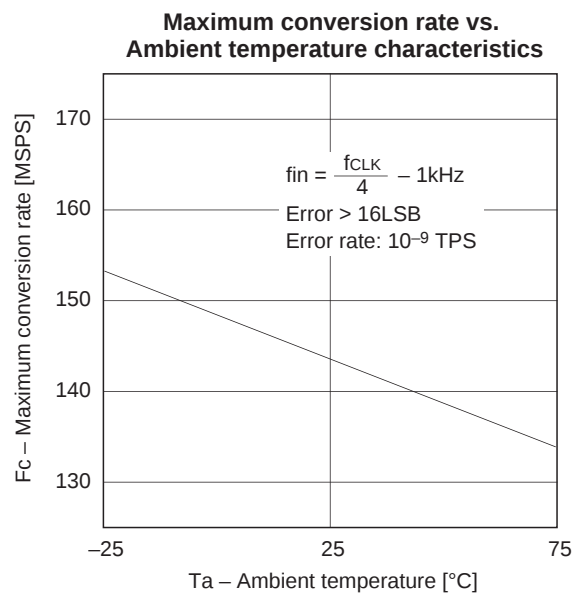
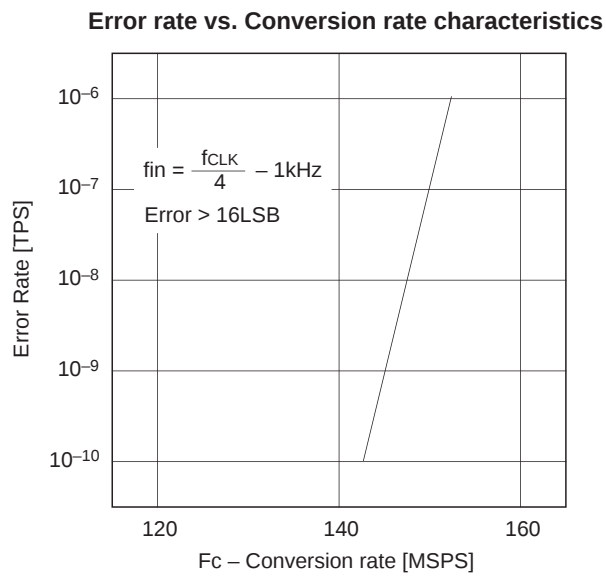
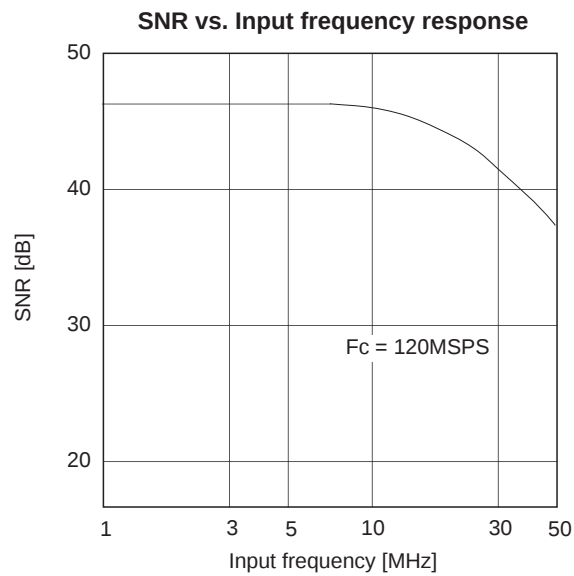


Notes on Operation

- The CXA3246Q has the PECL and TTL input pins for the clock and reset input pins. When the clock is input in PECL level, inputting the reset signal in PECL level is recommended. Also, when the clock is input in TTL level, inputting the reset signal in TTL is recommended.
- The impedance of the input signal should be properly matched to ensure the CXA3246Q's stable operation at the high speed.
- The power supply and grounding have a profound influence on converter performance. The power supply and grounding method are particularly important during high-speed operation. General points for caution are as follows.
 - The ground pattern should be as large as possible. It is recommended to make the power supply and ground patterns wider at an inner layer using a multi-layer board.
 - To prevent interference between AGND and DGND and between AVcc and DVcc, make sure the respective patterns are separated. To prevent a DC offset in the power supply pattern, connect the AVcc and DVcc lines at one point each via a ferrite-bead filter, etc. Shorting the AGND and DGND patterns in one place immediately under the A/D converter improves A/D converter performance.
 - Be sure to turn the analog and digital power supplies on simultaneously. If not simultaneously, the IC does not operate correctly.
 - Ground the power supply pins (AVcc, DVcc1, DVcc2, DV_{EE}3) as close to each pin as possible with a 0.1μF or larger ceramic chip capacitor.
(Connect the AVcc pin to the AGND pattern and the DVcc1, DVcc2 and DV_{EE}3 pins to the DGND pattern.)
 - It is recommended to place the ceramic chip capacitor of 0.1μF or more, in particular, between DVcc2 and DGND2 with the shortest distance. This has the effect to suppress the noise generated when the CXA3246Q TTL output circuit operates.
 - The digital output wiring should be as short as possible. If the digital output wiring is long, the wiring capacitance will increase, deteriorating the output slew rate and resulting in reflection to the output waveform since the original output slew rate is quite fast.
- The analog input pin V_{IN} has an input capacitance of approximately 10pF. To drive the A/D converter with the proper frequency response, it is necessary to prevent performance deterioration due to parasitic capacitance or parasitic inductance by using a large capacity drive circuit, keeping wiring as short as possible, and using chip parts for resistors and capacitors, etc.
- The V_{RT} and V_{RB} pins must have adequate by-pass to protect them from high-frequency noise. By-pass them to AGND with approximately 1μF tantal capacitor and 0.1μF chip capacitor as short as possible.
- If the CLKN/E pin is not used, by-pass this pin to DGND with an approximately 0.1μF capacitor. At this time, approximately DGND3 – 1.2V voltage is generated. However, this is not recommended for use as the threshold voltage V_{BB} because it is too weak.
- When the digital input level is ECL or PECL level, ^{***}/E pins should be used and ^{***}/T pins left open. When the digital input level is TTL, ^{***}/T pins should be used and ^{***}/E pins left open.
- The CXA3246Q TTL output high level is clamped to approximately 2.8V in the IC. This makes it possible to directly interface with the 3.5V system CMOS IC.
- The CXA3026Q has the output pins P1^{**} and P2^{**}. However, in the CXA3246Q, these symbols are changed as PA^{**} and PB^{**}. At this time, the P1 side of the CXA3026Q is changed to the PB side for the CXA3246Q; the P2 side of the CXA3026Q to the PA side for the CXA3246Q.
- The pipeline delay of the CXA3246Q is smaller by one clock, compared to that of CXA3026Q.

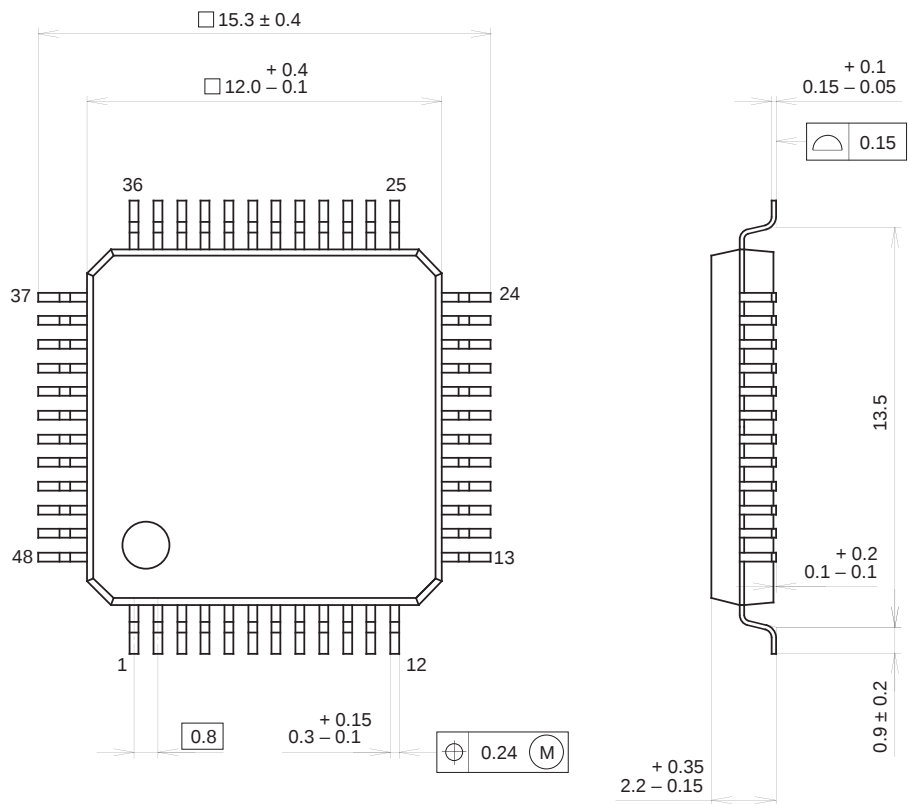
Example of Representative Characteristics





Package Outline Unit: mm

48PIN QFP (PLASTIC)



PACKAGE STRUCTURE

SONY CODE	QFP-48P-L04
EIAJ CODE	QFP048-P-1212
JEDEC CODE	_____

PACKAGE MATERIAL	EPOXY RESIN
LEAD TREATMENT	SOLDER / PALLADIUM PLATING
LEAD MATERIAL	42/COPPER ALLOY
PACKAGE MASS	0.7g

NOTE : PALLADIUM PLATING
This product uses S-PdPPF (Sony Spec.-Palladium Pre-Plated Lead Frame).