

TC5092AP C²MOS 13-BIT A/D CONVERTER

GENERAL DESCRIPTION

The TC5092AP is an integration 13-bit A/D converter of high precision and low power consumption. The 13-bit, 3-state data output is capable of independent enable in 4 bits so as to be connected directly to 4-bit/8-bit/12-bit data bus. (LSB is common to lower order 4 bits.)

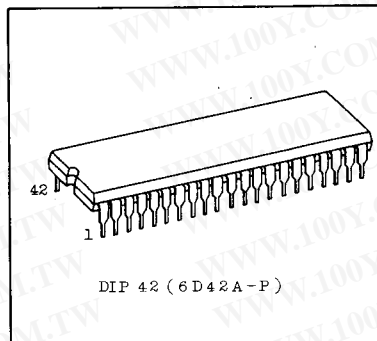
Further, since this converter has an 8-channel analog multiplexer, and a serial clock output function, it is most suitable as data collection unit of various industrial control instruments.

FEATURES:

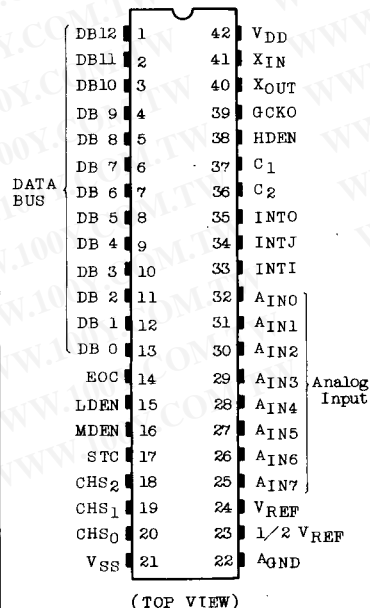
- High precision..... ± 1 LSB(Typ.)
- Low power consumption.....10mW(Typ.)
- Single power supply..... $V_{DD}=5V\pm 0.5V$
- High-speed conversion..... f_{CP} Max.=5MHz
- 8-channel analog multiplexer contained
- TLL/CMOS compatible digital Input/Output
- Capable of direct connection to 4-/8-/12-bit bus

APPLICATIONS:

- Various industrial control instruments
- Data collection modules



PIN ASSIGNMENT

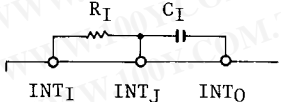


ABSOLUTE MAXIMUM RATINGS

CHARACTERISTIC	SYMBOL	RATING	UNIT
DC Supply Voltage	V _{DD}	V _{SS} -0.5 ~ V _{SS} +7	V
Input Voltage	V _{IN}	V _{SS} -0.5 ~ V _{DD} +0.5	V
Reference Supply Voltage	V _{REF}	V _{AGND} ~ V _{DD} +0.5	V
Analog Ground Voltage	V _{AGND}	V _{SS} -0.5 ~ V _{REF}	V
Output Voltage	V _{OUT}	V _{SS} -0.5 ~ V _{DD} +0.5	V
DC Input Current	I _{IN}	± 10	mA
Power Dissipation	P _D	300	mW
Operating Temperature Range	T _{opr}	-40 ~ 85	°C
Storage Temperature Range	T _{stg}	-65 ~ 150	°C

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FUNCTION OF EACH PIN

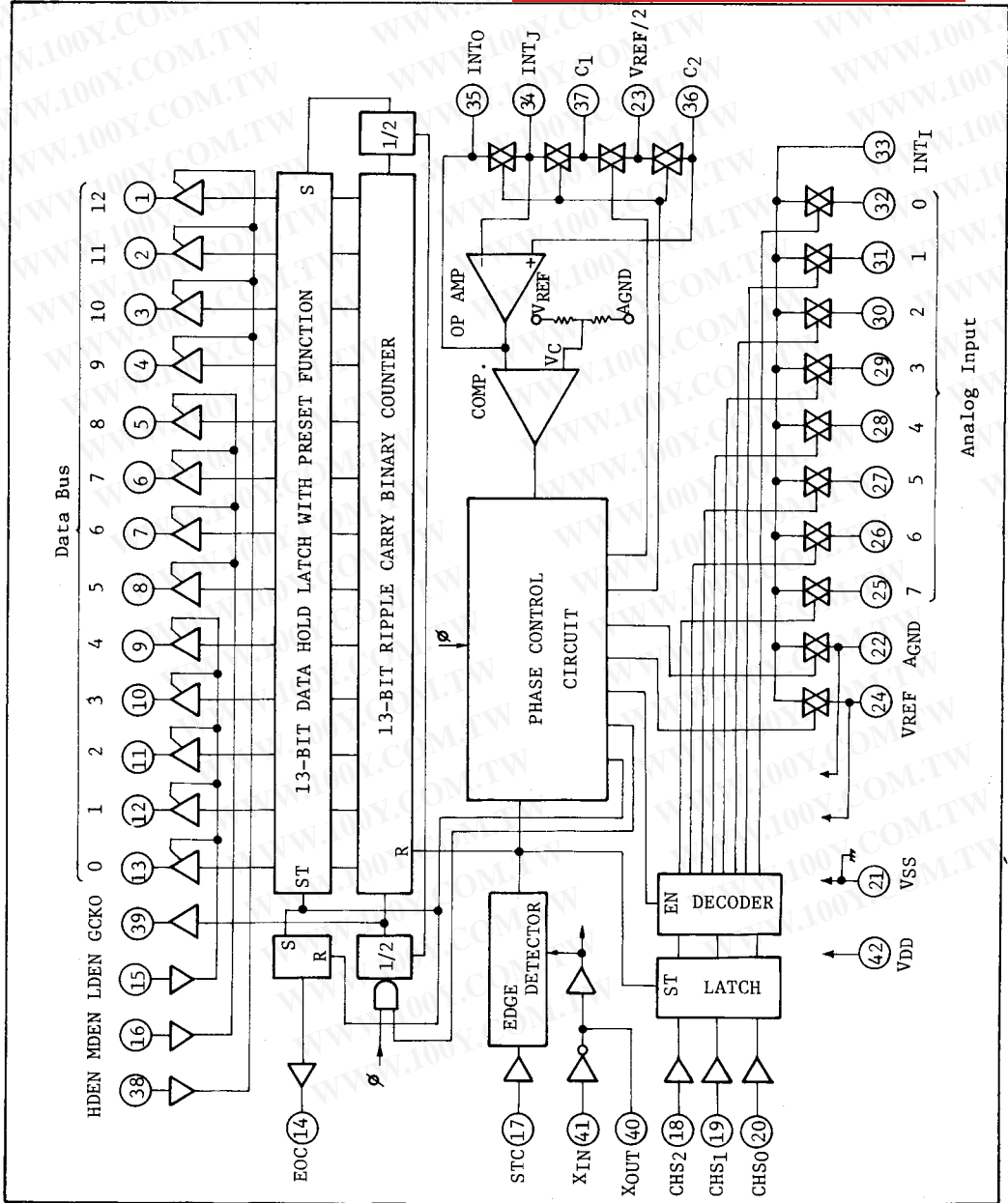
PIN NO.	Symbol	NAME & FUNCTION	PIN NO.	Symbol	NAME & FUNCTION																																				
1	DB12	3-State Parallel Data Outputs DB12 : MSB DB 0 : LSB	23	$V_{REF/2}$	Reference voltage supply terminal, which supplies the voltage of $\frac{V_{REF} - AGND}{2}$																																				
2	DB11																																								
3	DB10																																								
4	DB 9																																								
5	DB 8																																								
6	DB 7																																								
7	DB 6																																								
8	DB 5																																								
9	DB 4																																								
10	DB 3																																								
11	DB 2																																								
12	DB 1																																								
13	DB 0																																								
14	EOC	End of Conversion EOC goes to "L" level at the fall of STC signal, and returns to "H" level at the end of conversion.	24	V_{REF}	Reference voltage supply terminal																																				
15	LDEN	Low Data Enable DB ₀ ~ DB ₄ are read by "H" level input.	25	AIN7	Analog input terminal Input voltage range: AGND ~ V_{REF} Arbitrary input can be selected by CHS input.																																				
			26	AIN6																																					
16	MDEN	Medium Data Enable DB ₅ ~ DB ₈ are read by "H" level input.	27	AIN5	<table border="1"> <thead> <tr> <th>CHS0</th> <th>CHS1</th> <th>CHS2</th> <th>AIN</th> </tr> </thead> <tbody> <tr> <td>L</td> <td>L</td> <td>L</td> <td>AIN0</td> </tr> <tr> <td>H</td> <td>L</td> <td>L</td> <td>AIN1</td> </tr> <tr> <td>L</td> <td>H</td> <td>L</td> <td>AIN2</td> </tr> <tr> <td>H</td> <td>H</td> <td>L</td> <td>AIN3</td> </tr> <tr> <td>L</td> <td>L</td> <td>H</td> <td>AIN4</td> </tr> <tr> <td>H</td> <td>L</td> <td>H</td> <td>AIN5</td> </tr> <tr> <td>L</td> <td>H</td> <td>H</td> <td>AIN6</td> </tr> <tr> <td>H</td> <td>H</td> <td>H</td> <td>AIN7</td> </tr> </tbody> </table>	CHS0	CHS1	CHS2	AIN	L	L	L	AIN0	H	L	L	AIN1	L	H	L	AIN2	H	H	L	AIN3	L	L	H	AIN4	H	L	H	AIN5	L	H	H	AIN6	H	H	H	AIN7
			CHS0	CHS1		CHS2	AIN																																		
			L	L		L	AIN0																																		
			H	L		L	AIN1																																		
			L	H		L	AIN2																																		
			H	H		L	AIN3																																		
			L	L		H	AIN4																																		
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L	H	H	AIN6																																						
H	H	H	AIN7																																						
28	AIN4																																								
29	AIN3																																								
30	AIN2																																								
31	AIN1																																								
32	AIN0																																								
17	STC	Start Conversion Conversion starts at the fall time, if pulse input at "H" level is provided. "L" level should be kept during conversion.	33	INT _I	Integrator Input Integrator Junction Integrator Output The integrator consists of these three terminals.																																				
						34	INT _J																																		
18	CHS ₂	Channel Select Inputs These pins are address inputs for selecting eight analog inputs of AIN0 ~ AIN7, and are taken into the internal latch	35	INT _O	 <p>$R_I \cdot C_I > \frac{13000}{f_{OSC}} [S]$</p> <p>However, R of 1 ~ 2MΩ should be used.</p>																																				
19	CHS ₁																																								
20	CHS ₀																																								
21	V _{SS}	Digital Ground	36	C ₂	Capacitors connection terminals for offset calibration.																																				
22	AGND	Analog Ground																																							

FUNCTION OF EACH PIN

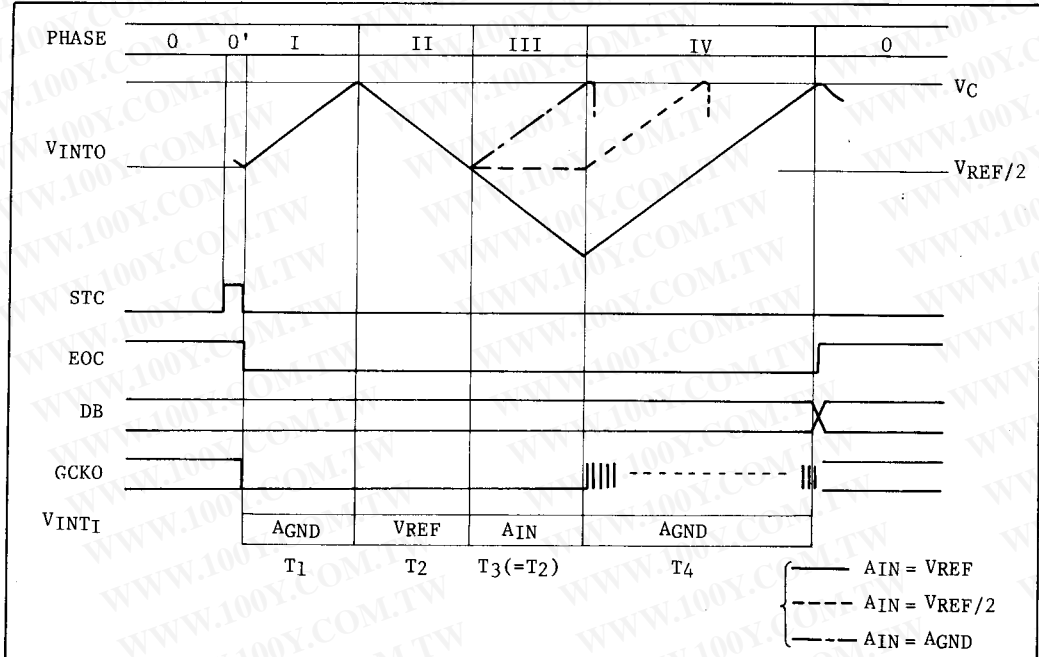
PIN NO.	Symbol	NAME & FUNCTION
37	C ₁	0.1 μ F is connected between C2 and C1, and 0.01 μ F C1 and VSS, respectively.
38	HDEN	High Data Enable DB9 ~ DB12 are read by "H" level input.
39	GCKO	Gated Clock Output Pulses of number equivalent to conversion data are output during conversion.
40	XOUT	Terminals for system clock oscillation. Crystal oscillators are connected to both the ends of terminals.
41	XIN	
42	VDD	Supply Voltage 5V \pm 0.5V

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SYSTEM DIAGRAM



TIMING CHART



FUNCTIONAL DESCRIPTION

(1) Conversion cycle

In the state of PHASE 0', the operation of LSI is at a stop and the integrating amplifier performs as voltage follower. Under this condition the external capacitor (0.1 μ F across C₁ and C₂)

When STC is given, the offset voltage charged into external capacitors is applied to non-inversion of the integrator, thus cancelling the offset voltage equivalently. In PHASE I, the integrator continues to integrate AGND until its output reaches V_C.

In PHASE III the integrator integrates the analog input for the same period of time as T₂ after it has integrated V_{REF} for a fixed period of time (T₂) in PHASE II.

Finally, in PHASE IV the integrator continues to integrate AGND until its output reaches V_C.

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FUNCTIONAL DESCRIPTION

Let the time in PHASE IV be T_4 . Then the following equation is made (formed) by omitting error factors such as offset drift.

$$V_{AIN} = \frac{T_4}{2T_2} V_{REF} \quad (AGND=0V) \dots (1)$$

In case of this LSI, T_2 is designed by $4096 \times 2 \cdot T_{OSC}$ (T_{OSC} denotes reference clock synchronization). Therefore, the above formula letting $2 \cdot T_{OSC}$ be T is changed as follows:

$$\frac{V_{AIN}}{V_{REF}} = \frac{T_4}{8192T} \dots (2)$$

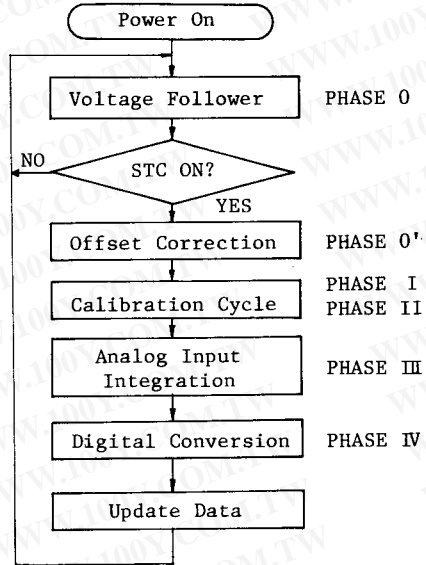
That is, 13-bit resolution A/D conversion of FS (full scale) = 8192 can be made by counting the period of T_4 by use of a clock having T frequency.

However, it is recommended that R_I and C_I composing the integrator be set to the values close to $13000/f_{OSC}$ as possible after having satisfied the following formula.

$$R_I C_I > 13000 / f_{OSC}, R_I = 1 \sim 2M\Omega \text{ is used.} \dots (3)$$

(2) Output data format

13-bit output data are output to 13 independent 3-state data buses $DB_0 \sim DB_{12}$. Since 13-bit outputs can be independently placed on 3-state every group of High, Medium and Low of 4 bits/4 bits/5 bits from the higher order, it is easy to connect the microcomputer to buses of 4, 8, 12 bits.



FUNCTIONAL DESCRIPTION

TRUTH TABLE

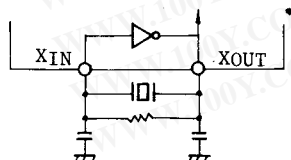
LDEN	MDEN	HDEN	Analog Input	DATA OUTPUTS (DB)												
				0	1	2	3	4	5	6	7	8	9	10	11	12
L	L	L	Don't Care	Z				Z				Z				
H	L	L		D	D	D	D	D	Z				Z			
L	H	L		Z				D	D	D	D	Z				
H	H	L		D	D	D	D	D	D	D	D	Z				
L	L	H		Z				Z				D	D	D	D	
H	L	H		D	D	D	D	D	Z				D	D	D	D
L	H	H		Z				D	D	D	D	D	D	D	D	
H	H	H	<1/2LSB	L	L	L	L	L	L	L	L	L	L	L	L	
			1/2LSB ~ 3/2LSB	H	L	L	L	L	L	L	L	L	L	L	L	
			Straight Binary												
			"FS"-5/2LSB ~ "FS"-3/2LSB	L	H	H	H	H	H	H	H	H	H	H	H	H
			"FS"-3/2 LSB <	H	H	H	H	H	H	H	H	H	H	H		

Note : FS Full Scale, 1 LSB = (VREF-AGND)/8192, Z ... High Impedance
 D ... "H" or "L" Level

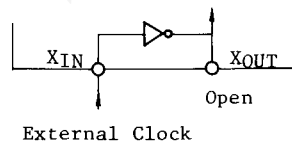
(3) Basic clock

Since this LSI operates on the basis of the frequency given to XIN input, a stable clock ($\Delta f < 0.005\%$) must be used for the clock to be given to XIN.

Therefore, it is proper that the oscillation circuit is configured as shown in the following figure (a) by the use of externally mounted crystal because the LSI has a built-in inverter for crystal oscillation.



(a)



(b)

FUNCTIONAL DESCRIPTION

(4) How to give STC input, Conversion time, and Sampling cycle

STC input is taken in with the reference clock of LSI, but the positive pulse having the pulse width for at least two cycles is required for internal starting. The conversion time of from the fall of STC input to the rise of EOC output. Letting this time be $T_c \text{ MAX}$ (Maximum conversion time), then the following equation is obtained.

$$T_c \text{ MAX} = 41000 \times T_{\text{OSC}} \text{ [S]} \dots\dots\dots (4)$$

(where T_{OSC} is oscillation cycle of basic clock.)

For example, when $f_{\text{CP}}=5\text{MHz}$, $T_c \text{ MAX}=8.2\text{ms}$. For one-time sampling, an accurate output can be obtained from the falling edge of STC input after the lapse of $T_c \text{ MAX}$.

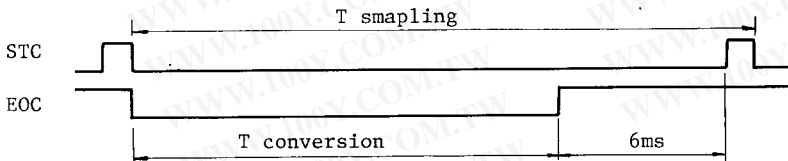
For consecutive sampling, however, STC input must be given after the lapse of a given period of time (6ms) from the rise of EOC. This period (6ms) is the time required for the recovery of LSI to normal state.

Therefore, the minimum sampling cycle $T_s \text{ MIN}$ is as follows:

$$T_s \text{ MIN} = 41000 \times T_{\text{OSC}} + 0.006 + t_w(\text{STC}) \text{ [S]} \dots\dots\dots (5)$$

Note: When power is set ON, following start-up procedure is required due to indefinite state of internal circuitry.

1. Applying clock, STC is to be set high over 10ms.
2. Complete at least one cycle as a dummy conversion cycle.

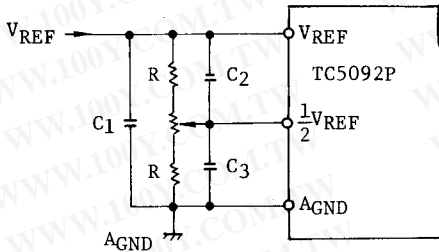


(5) Reference voltage

This LSI has three reference input voltage terminals of A_{GND} , $\frac{1}{2} V_{\text{REF}}$, and V_{REF} . Since analog input signal is quantized to 1/8192 in the range of $A_{\text{GND}} \sim A_{\text{REF}}$ for digitization, stable voltages must be supplied to $\frac{1}{2} V_{\text{REF}}$ and V_{REF} .

FUNCTIONAL DESCRIPTION

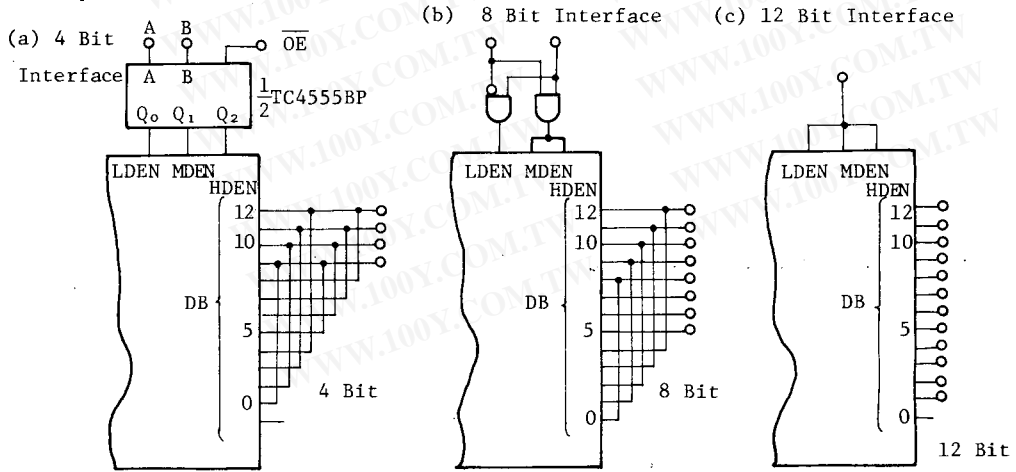
Especially the value of $\frac{1}{2} V_{REF}$ voltage has direct effects upon conversion accuracy; therefore, it is recommended that adjustment be made so as to agree output data with analog input by actually making A/D convert by use of input voltage at FS (full scale) or 1/2FS level.



The left figure shows an example of reference voltage supplying circuit. $C_1 \sim C_3$ are filter capacitors for preventing reference voltage variations to be caused by ripple or induction noise. Generally the value of capacitor is about $0.01 \sim 0.1 \mu F$, though it varies with the system.

(6) BUS Interface

For connecting a microcomputer to BUS line, three independent enable terminals are used. These three enable terminals permit the processing in the unit of 4 bits (5 bits for the low order digit only). The microcomputer can be directly connected to the BUS of 4 ~ 12 bits easily by allocating proper address of microcomputer to the TC5092AP.



RECOMMENDED OPERATING CONDITION

ITEM	SYMBOL	MIN.	TYP.	MAX.	UNIT
Supply Voltage	VDD	4.5	5.0	5.5	V
Digital Input Voltage	VIN	0	-	VDD	V
Analog Input Voltage	VAIN	AGND	-	VREF	-
Reference Supply Voltage	VREF	4.0	-	VDD	V
Analog Ground Voltage	VAGND	0	0	0.5	V

ELECTRICAL CHARACTERISTICS (VDD = 5V ± 10%, VSS = 0V, Ta = -40 ~ 85°C)

ITEM	SYMBOL	TEST CONDITION	VDD (V)	MIN.	TYP.	MAX.	UNIT	
Output High Voltage	VOH	I _{OH} = -1μA, Digital output	5	4.9	5.0	-	V	
Output Low Voltage	VOL	I _{OL} = 1μA, Digital output	5	-	0.0	0.1	V	
Input High Voltage	VIH	Digital Input except XIN	5	2.4	-	-	V	
		XIN	5	4.5	-	-		
Input Low Voltage	VIL	Digital Input except XIN	5	-	-	0.8	V	
		XIN	5	-	-	0.5		
Output High Current	I _{OH}	VOH = 2.4V Digital output except X _{OUT}	4.75	-1.0	-	-	mA	
Output Low Current	I _{OL}	VOL = 0.4V Digital output except X _{OUT}	4.75	1.6	-	-	mA	
Output Disable Current	IDH	VOH = 5.5V, DB ₀ ~ DB ₁₂	5.5	-	10 ⁻³	5	μA	
	IDL	VOL = 0.0V, DB ₀ ~ DB ₁₂	5.5	-	-10 ⁻³	-5		
Input Current	I _{IH}	VIN = 5.5V, Digital input	5.5	-	10 ⁻⁵	1.0	μA	
	I _{IL}	VIL = 0.0V, Digital input	5.5	-	-10 ⁻⁵	-1.0		
Analog Switch Off-Leak	I _{OFF}	Analog input/output	5.5	-	±10 ⁻⁴	-	μA	
Analog Switch On Resistor	RON	RL = 10kΩ	5	-	-	-	Ω	
Operating Consumption Current	I _{DD}	VREF = VDD Digital output open	f _{CP} = 5MHz	5	-	2	-	mA
		Digital input GND	f _{CP} = 1MHz	5	-	1	-	

SWITCHING CHARACTERISTICS ($V_{DD} = 5V \pm 10\%$, $V_{SS} = 0V$, $T_a = 25^\circ C$, $C_L = 50pF$)

ITEM	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Output Rise Time	t_{TLH}	Digital output	-	50	150	ns
Output Fall Time	t_{THL}	Digital output	-	40	150	
Output Enable Time	t_{ZL} t_{ZH}	LDEN } MDEN } HDEN } -DB Output	-	80	250	ns
Output Disable Time	t_{LZ} t_{HZ}		-	280	500	
Max. Clock Frequency	$f_{MAX\phi}$	X_{IN} Duty 40~60%	5.0	-	-	
Min. Clock Frequency	$f_{MIN\phi}$	X_{IN} Duty 40~60%	-	-	-	MHz
Input Capacity	C_{IN}	Digital input	-	5	-	pF
	C_{IN}	Analog input	-	-	-	
3-State Output Capacity	C_{OUT}	DB Output	-	8	-	

SYSTEM CHARACTERISTICS ($V_{DD} = 5V \pm 10\%$, $V_{SS} = 0V$, $T_a = 25^\circ C$)

ITEM	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Resolution	n		-	13	-	Bit
Conversion Time	T_c	$f_{CP} = 5$ MHz	-	-	8.2	ms
		$f_{CP} = 1$ MHz	-	-	41	
Sampling Cycle	T_{SPL}	$f_{CP} = 5$ MHz	14.2	-	-	ms
		$f_{CP} = 1$ MHz	47	-	-	
Nonlinearity		$V_{DD} = V_{REF}$	-	± 1		LSB
Zero Scale Error	EZP		-	± 2		
Full Scale Error	EFS		-	± 1		
STC Min. Pulse Width	t_w		-	-	$2/f_{OSC}$	s

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