HD14443B, HD14447B

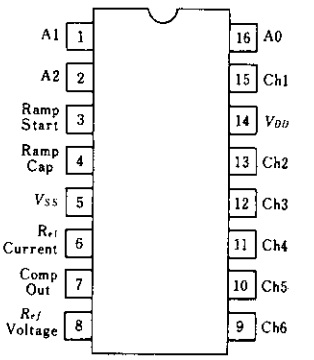
Analog to Digital Converter Linear Subsystem

The HD14443B and the HD14447B devices are 6 channel, single slope, 8 to 10 bit analog to digital converter linear subsystems for microprocessor based data and control, systems. Contained in both devices are a one of 8 decoder, an 8 channel analog multiplexer, a buffer amplifier, a precision voltage to current converter, a ramp start circuit and a comparator. The output driver of the HD14443B comparator is an open-drain N-channel capable of sinking up to 5mA of current. The output of the HD14447B comparator has a standard B-Series P-channel, N-channel pair. A processor system provides the addressing, timing, counting, and arithmetic operations required for implementing a full analog to digital converter system. A system made up of a processor and the linear subsystem has features such as automatic zeroing and variable scaling (weighting) of six separate analog channels.

■ FEATURES

- Quiescent Current = 1.6mA typ. @5V
- Single Supply Operation = 4.5 to 18V
- MPU Compatible
- Typical Resolution = 8 bits
- Typical Conversion Cycle as Fast as 300μs
- Ratio Metric Conversion Minimizes Error

■ PIN ARRANGEMENT

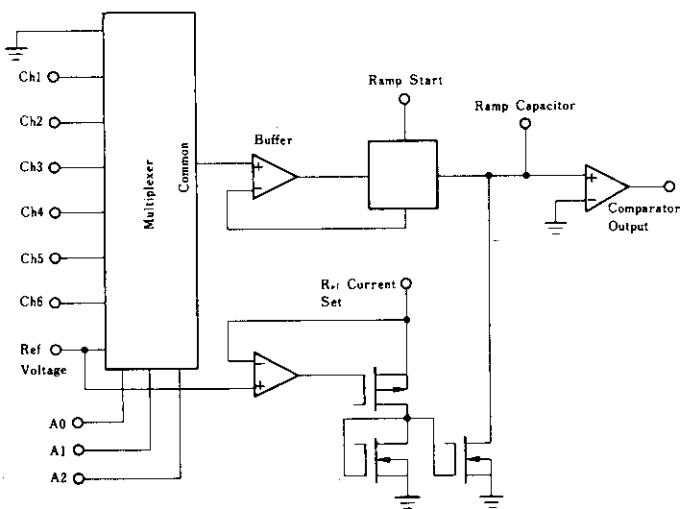


(Top View)

■ TRUTH TABLE

A2	A1	A0	Input Selected
0	0	0	V_{SS} Channel 0 (Ground)
0	0	1	Ch1 Channel 1
0	1	0	Ch2 Channel 2
0	1	1	Ch3 Channel 3
1	0	0	Ch4 Channel 4
1	0	1	Ch5 Channel 5
1	1	0	Ch6 Channel 6
1	1	1	V_{Ref} Channel 7 (External Reference)

■ BLOCK DIAGRAM



■ ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	V_{DD}(V)	Test Conditions	−40℃ min	−40℃ max	25℃ min	25℃ typ	25℃ max	85℃ min	85℃ max	Unit
Output Voltage (Comparator)	V_{OL}	5.0	V_{in}(Pin 4)=0V	−	0.05	−	0.01	0.05	−	0.05	V
		10		−	0.05	−	0.01	0.05	−	0.05	
		15		−	0.05	−	0.01	0.05	−	0.05	
	V_{OH}	5.0	V_{in}(Pin 4)=1.0V (R_L=10kΩ to V_{DD} HD14443B only)	4.95	−	4.95	4.99	−	4.95	−	V
		10		9.95	−	9.95	9.99	−	9.95	−	
		15		14.95	−	14.95	14.99	−	14.95	−	
Input Voltage (A0·A1·A2·Ramp Start)	V_{IL}	5.0	V_{out}=4.5 or 0.5V	−	1.5	−	2.25	1.5	−	1.5	V
		10	V_{out}= 9.0 or 1.0V	−	3.0	−	4.50	3.0	−	3.0	
		15	V_{out}=13.5 or 1.5V	−	4.0	−	6.75	4.0	−	4.0	
	V_{IH}	5.0	V_{out}= 0.5 or 4.5V	3.5	−	3.5	2.75	−	3.5	−	V
		10	V_{out}= 1.0 or 9.0V	7.0	−	7.0	5.50	−	7.0	−	
		15	V_{out}= 1.5 or 13.5V	11.0	−	11.0	8.25	−	11.0	−	
Output Drive Current (Comparator)	I_{OH}	5.0	V_{in}(Pin 4)=1.0V (HD14447B only) V_{OH}=2.5V	−2.5	−	−2.1	−4.2	−	−1.7	−	mA
		5.0	V_{OH}=4.6V	−0.52	−	−0.44	−0.88	−	−0.36	−	
		10	V_{OH}=9.5V	−1.3	−	−1.1	−2.25	−	−0.9	−	
		15	V_{OH}=13.5V	−3.6	−	−3.0	−8.8	−	−2.4	−	
	I_{OL}	5.0	V_{in}(Pin 4)=0V V_{OL}=0.4V	0.52	−	0.44	0.88	−	0.36	−	mA
		10	V_{OL}=0.5V	1.3	−	1.1	2.25	−	0.9	−	
		15	V_{OL}=1.5V	3.6	−	3.0	8.8	−	2.4	−	
Input Current (A0·A1·A2·Ramp Start)	I_{in}	15		−	±0.3	−	−	±0.3	−	±1.0	μA
Input Current (Analog Inputs)	I_{in}	15		−	−	−	±0.1	±10	−	−	nA
Input Capacitance (A0·A1·A2·Ramp Start)	C_{in}	15	V_{in}=0V	−	−	−	5.0	7.5	−	−	pF
Quiescent Current	I_{DD}	5.0	Zero Signal, per Package	−	−	−	1.6	−	−	−	mA
		10		−	−	−	3.0	−	−	−	
		15		−	−	−	3.4	−	−	−	
Crosstalk Between Any Tow Input Channels	V_{ct}			−	−	−	0	4.0	−	−	mV
Reference Current Range	I_R			−	−	10	−	40	−	−	μA
Common Mode Input Voltage	V_{CM}	5.0		−	−	0	−	2.5	−	−	V
		10		−	−	0	−	7.0	−	−	
		15		−	−	0	−	12	−	−	
Buffer Amplifier Output Offset	V_{BO}	5.0		−	−	−	0.285	−	−	−	V
		10		−	−	−	0.400	−	−	−	
		15		−	−	−	0.420	−	−	−	
Comparator Threshold	V_{TC}	5.0		−	−	−	0.195	V_{BO} −0.04	−	−	V
		10		−	−	−	0.275	V_{BO} −0.04	−	−	
		15		−	−	−	0.290	V_{BO} −0.04	−	−	
Reference Voltage Range	V_R	5.0		−	−	2.0	−	2.5	−	−	V
		10		−	−	2.0	−	7	−	−	
		15		−	−	2.0	−	12	−	−	
Conversion Linearity	L_C		V_{in}=V_{DD}−3V, C>100pF	−	−	−	0.15	0.3	−	−	% Full Scale

■ SWITCHING CHARACTERICS (C_L=50pF, Ta=25°C)

Characteristic		Symbol	V_{DD}(V)	min	typ	max	Unit
Output Rise Time (Comparator) (HD14447B only)		t_r	5.0	–	120	240	ns
			10	–	75	150	
			15	–	65	130	
Output Fall Time (Comparator)		t_f	5.0	–	250	500	ns
			10	–	350	700	
			15	–	650	1300	
Propagation Delay Time (Comparator)	HD14443B (R_L=10kΩ to V_{DD})	t_{PLH}	5.0	–	750	1500	ns
			10	–	600	1200	
			15	–	550	1100	
		t_{PHL}	5.0	–	500	1000	ns
			10	–	300	600	
			15	–	300	600	
	HD14447B	t_{PLH}	5.0	–	600	1200	ns
			10	–	475	950	
			15	–	500	1000	
		t_{PHL}	5.0	–	450	980	ns
			10	–	540	1080	
			15	–	750	1500	
Multiplexer Propagation Delay		t_M	5.0	–	300	600	ns
			10	–	200	400	
			15	–	180	360	
Ramp Start Delay Time		t_{TS}	5.0	–	40	80	ns
			10	–	25	50	
			15	–	20	40	
Acquisition Time (C=1000pF)*		t_A	5.0	–	–	60	μs
			10	–	–	30	
			15	–	–	28	

* Acquisition Time includes multiplexer propagation delay, ramp start propagation delay and the time required to charge ramp capacitor to the selected input voltage.

■ DEVICE OPERATION

• ADDRESS INPUTS SELECT (A0, A1, A2, Pins 1, 2, 16)

The input voltage source to be presented to the measurement system according to the Truth Table.

• RAMP START (Ramp Start, Pin 3)

When the Ramp Start is low, the ramp capacitor is charged to a voltage associated with the selected input channel. When the Ramp Start is brought high, the connection to the input channel is broken and the capacitor begins to ramp toward V_{SS}.

• RAMP CAPACITOR (Ramp Cap, Pin 4)

The ramp capacitor is used to generate a time period when discharged from a selected voltage via a precise reference current.

• NEGATIVE POWER SUPPLY (V_{SS}, Pin 5)

This pin is system ground.

• REFERENCE CURRENT (ref. Current, Pin 6)

To discharge the ramp capacitor, the reference current is fixed via a resistor (R_{Ref}) to a positive supply from pin 6. Typical current is equal to $(V_{DD}-V_{Ref})/R_{Ref}$.

• COMPARATOR OUTPUT (Comp Out, Pin 7)

This output is low when the capacitor has reached the discharged voltage and is high otherwise.

• REFERENCE VOLTAGE (Ref Voltage, Pin 8)

This voltage can be set to a voltage between V_{SS} = 2V and V_{DD}-2V. This is the known voltage to which the unknown is compared.

• INPUT CHANNELS (Pins 9, 10, 11, 12, 13, 15)

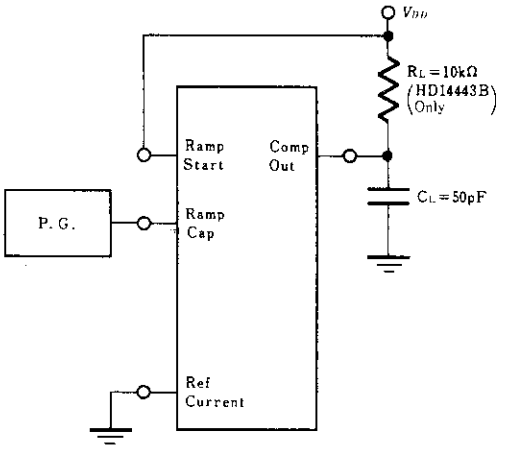
Input channels 1 through 6 are used to monitor up to six separate unknown voltage. Selection is via the address inputs.

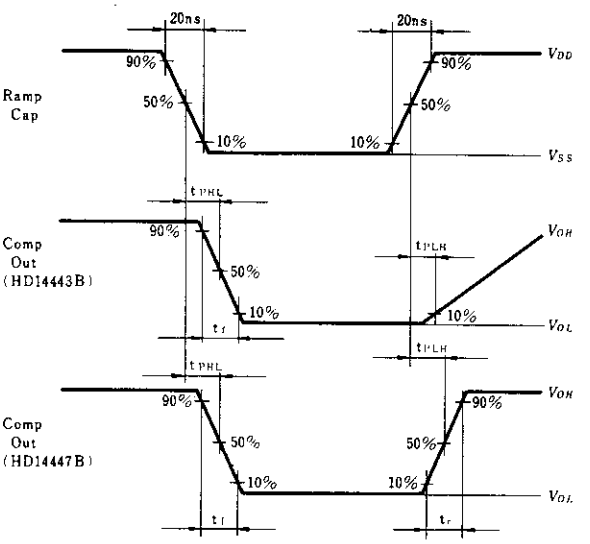
• POSITIVE POWER SUPPLY (V_{DD}, Pin 14)

This pin is the package positive power supply pin.

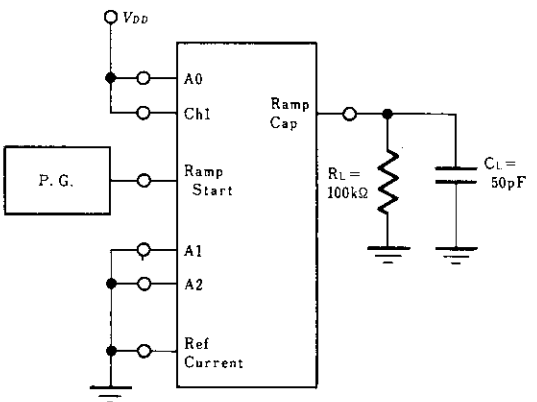
■ SWITCHING TIME TEST CIRCUIT (Ta=25℃)

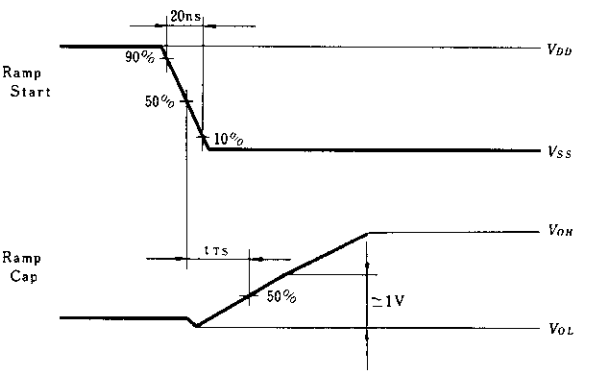
1. t_r, t_f, t_{PLH}, t_{PHL}





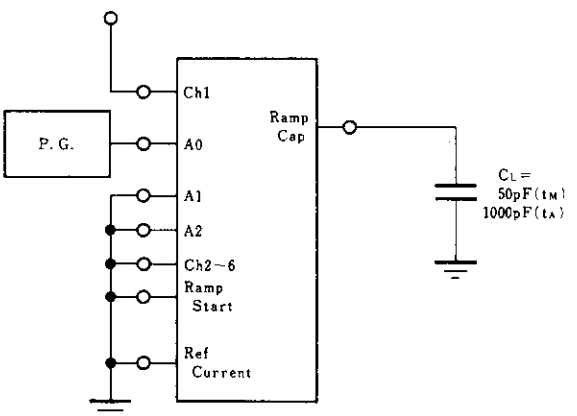
2. t_{TS}

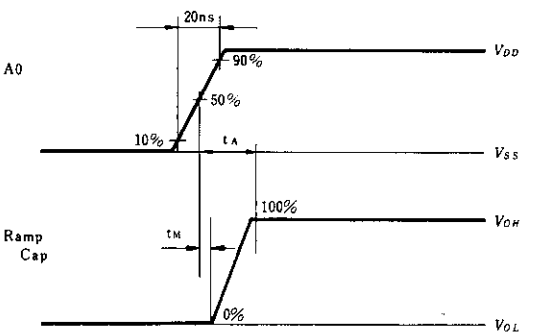




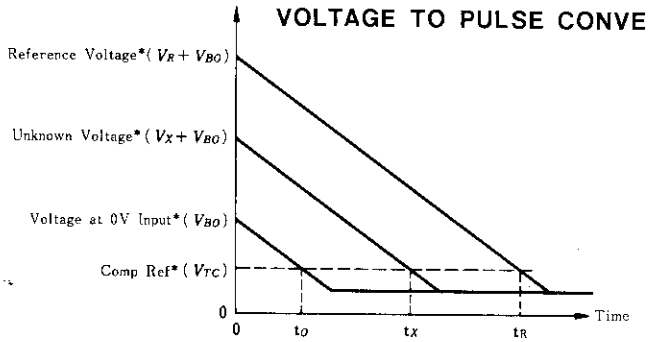
3. t_M, t_A

2.5V (V_{DD}=5.0V)
7V (V_{DD}=10V)
12V (V_{DD}=15V)





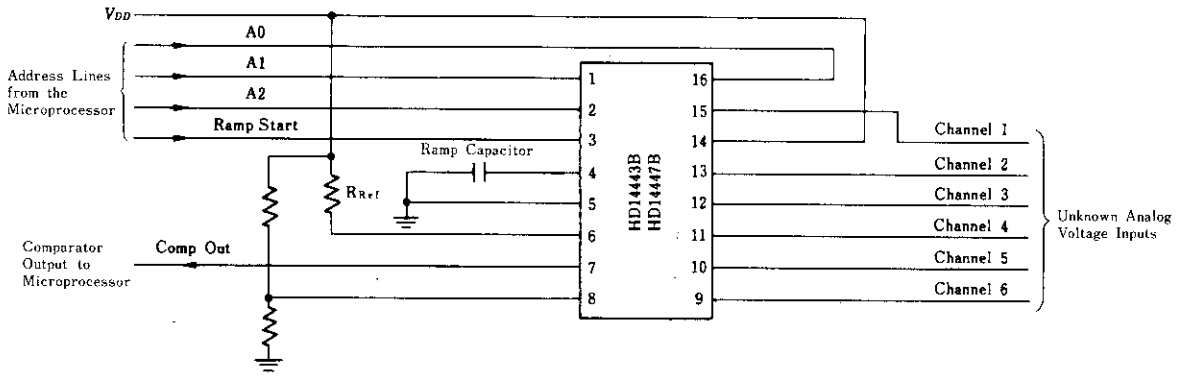
VOLTAGE TO PULSE CONVERSION



$(V_{BO})_{count} = t_O$
$(V_X + V_{BO})_{count} = t_X$
$(V_R + V_{BO})_{count} = t_R$
$(V_R)_{count} = t_R - t_O$
$(V_X)_{count} = t_X - t_O$
$\frac{(V_X)_{count}}{(V_R)_{count}} = \frac{t_X - t_O}{t_R - t_O}$
$(V_X)_C = (V_R)_C \frac{t_X - t_O}{t_R - t_O}$

* Voltages measured at pin 4 with ramp start low.

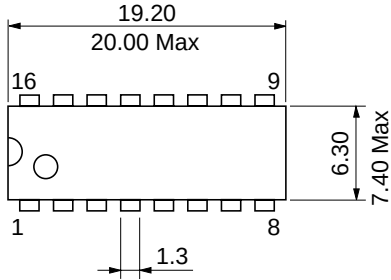
TYPICAL APPLICATIONS CIRCUIT

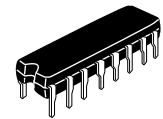


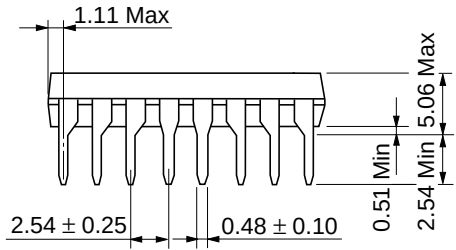
■ CONVERSION SEQUENCE

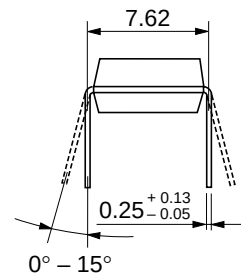
Step No.	A2	A1	A0	Ramp Start	Comment
1	1	1	1	0	Channel 7 Selected (Reference Voltage)
2	1	1	1	1	Record time until Pin 7 goes low
3	0	0	0	0	Channel 0 Selected (Ground)
4	0	0	0	1	Record time until Pin 7 goes low
5	0	0	1	0	Channel 1 Selected
6	0	0	1	1	Record time until Pin 7 goes low
Calculate tch7-tch0 = tch7′ Step2-Step4					
Calculate tch1-tch0 = tch1′ Step6-Step4					
Calculate Vunknown = Vch7 (tch1′/tch7′)					
7	0	1	0	0	Channel 2 Selected
8	0	1	0	1	Record time until Pin 7 goes low
Calculate tch2-tch0 = tch2′					
Calculate Vunknown = Vch7 (tch2′/tch7′)					
etc.					

Unit: mm









Hitachi Code	DP-16
JEDEC	Conforms
EIAJ	Conforms
Weight (reference value)	1.07 g

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