

# HD14443B, HD14447B

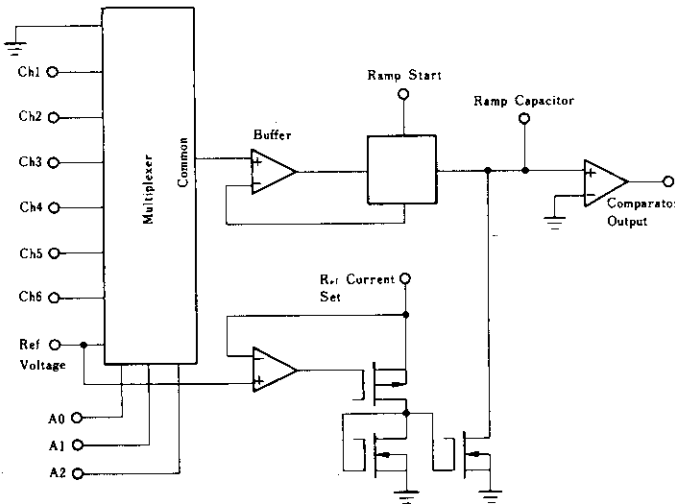
## Analog to Digital Converter Linear Subsystem

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.

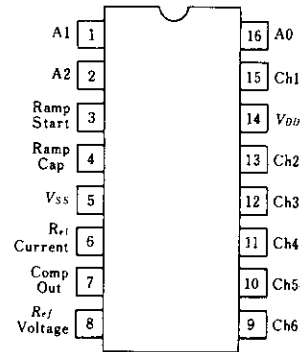
### ■ FEATURES

- 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 300 $\mu$ s
- Ratio Metric Conversion Minimizes Error

### ■ BLOCK DIAGRAM



### ■ PIN ARRANGEMENT



(Top View)

### ■ TRUTH TABLE

A2	A1	A0	Input Selected
0	0	0	V <sub>SS</sub> 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 <sub>Ref</sub> Channel 7 (External Reference)

■ ELECTRICAL CHARACTERISTICS

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

## ■ SWITCHING CHARACTERISTICS ( $C_L=50\text{pF}$ , $T_a=25^\circ\text{C}$ )

Characteristic		Symbol	$V_{DD}(\text{V})$	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 ( $R_L=10\text{k}\Omega$ 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 ( $C=1000\text{pF}$ )*		$t_A$	5.0	—	—	60	$\mu\text{s}$
			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  $V_{SS} = 2\text{V}$  and  $V_{DD}-2\text{V}$ . This is the known voltage to which the unknown is compared.

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

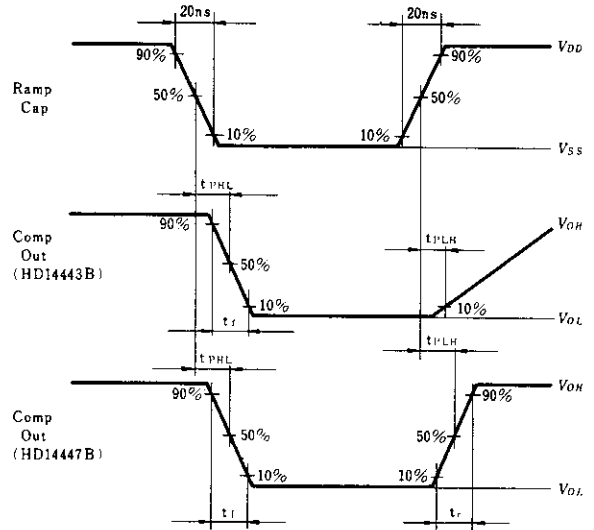
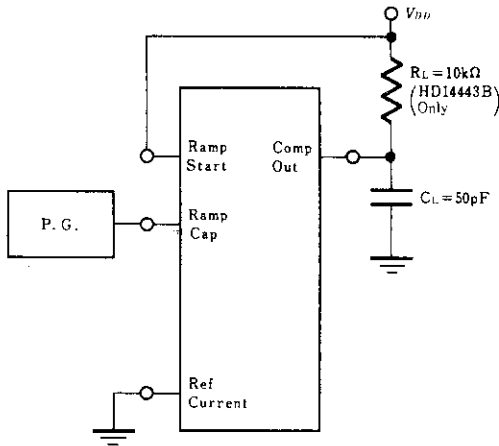
Input channels 1 through 6 are used to monitor up to six separate unknown voltage. Selection is via the address inputs.

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

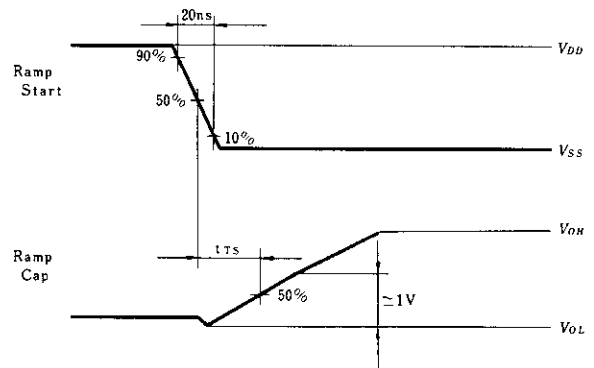
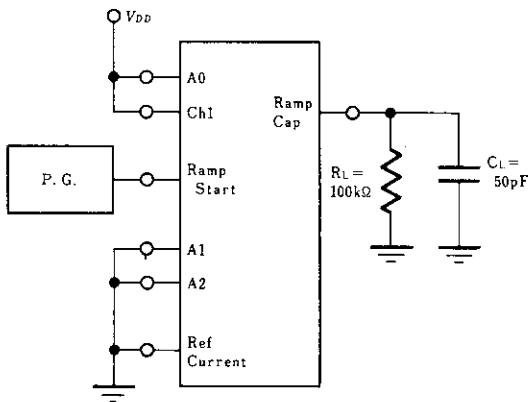
This pin is the package positive power supply pin.

■ SWITCHING TIME TEST CIRCUIT ( $T_a=25^{\circ}\text{C}$ )

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

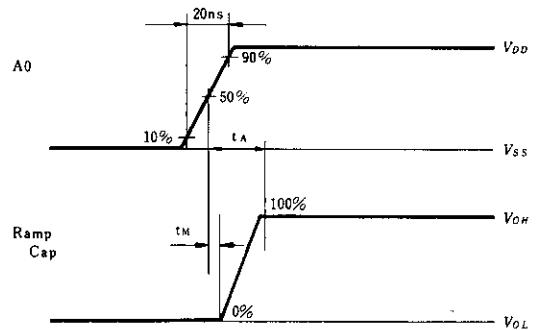
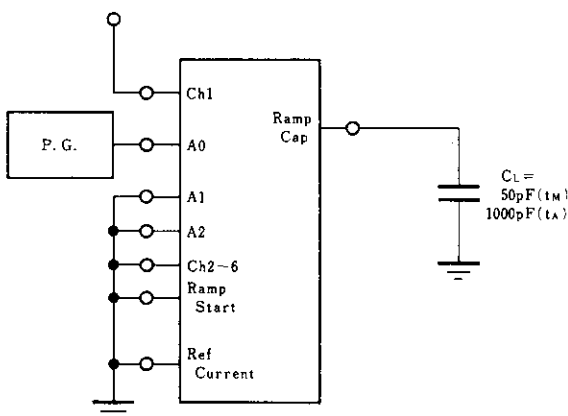


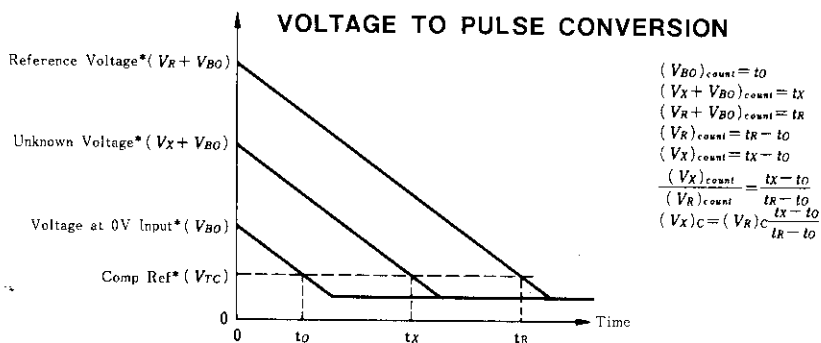
2.  $t_{TS}$



3.  $t_M, t_A$

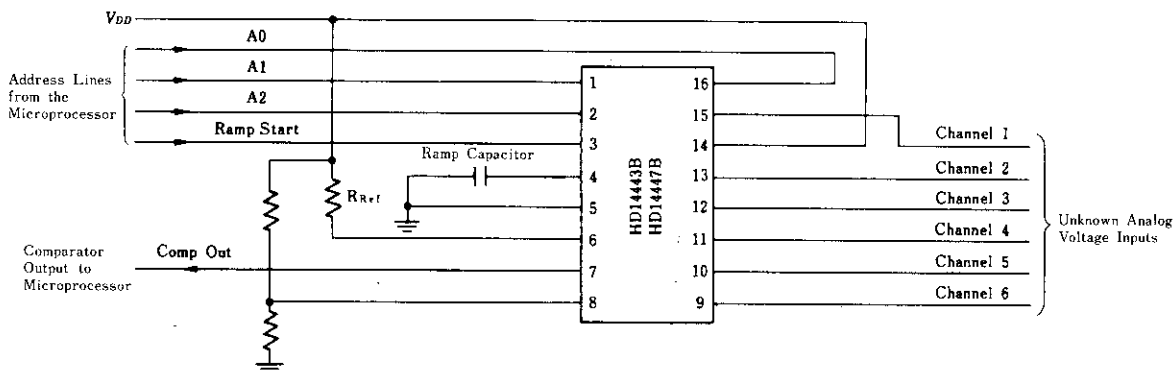
2.5V ( $V_{DD}=5.0\text{V}$ )  
 7V ( $V_{DD}=10\text{V}$ )  
 12V ( $V_{DD}=15\text{V}$ )





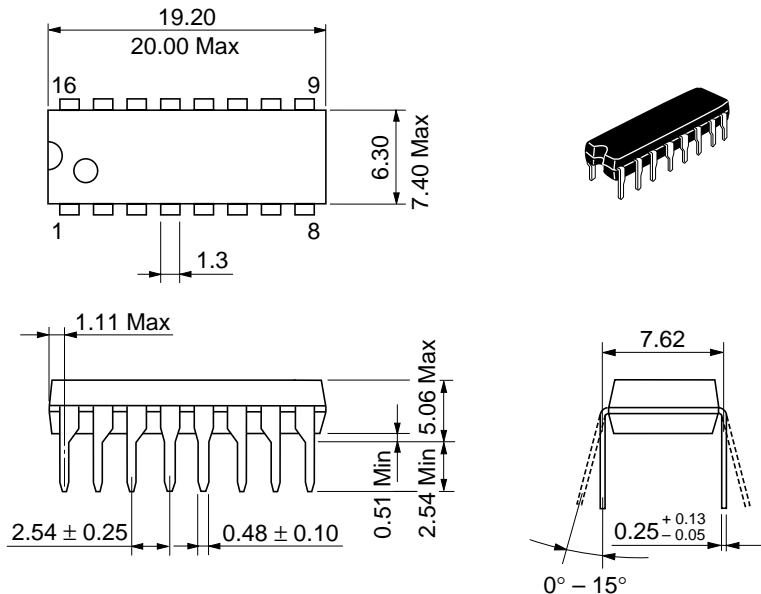
\* Voltages measured at pin 4 with ramp start low.

### 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 $t_{ch7} - t_{ch0} = t_{ch7}'$ Step2-Step4					
Calculate $t_{ch1} - t_{ch0} = t_{ch1}'$ Step6-Step4					
Calculate $V_{unknown} = V_{ch7} (t_{ch1}' / t_{ch7}')$					
7	0	1	0	0	Channel 2 Selected
8	0	1	0	1	Record time until Pin 7 goes low
Calculate $t_{ch2} - t_{ch0} = t_{ch2}'$					
Calculate $V_{unknown} = V_{ch7} (t_{ch2}' / t_{ch7}')$					
etc.					



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

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