



T-73-53

## Ultrafast Comparators

### AD96685/AD96687

#### FEATURES

Fast: 2.5ns Propagation Delay  
 Low Power: 118mW per Comparator  
 Packages: DIP, TO-100, SOIC, PLCC  
 Power Supplies: +5V, -5.2V  
 Logic Compatibility: ECL  
 MIL-STD-883 Versions Available  
 50ps Delay Dispersion

#### APPLICATIONS

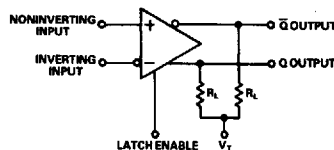
High Speed Triggers  
 High Speed Line Receivers  
 Threshold Detectors  
 Window Comparators  
 Peak Detectors

#### GENERAL DESCRIPTION

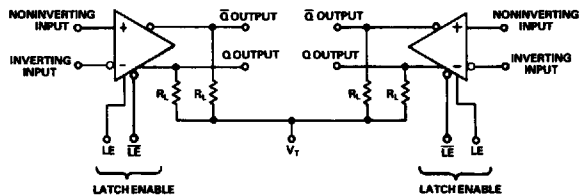
The AD96685 and AD96687 are ultrafast voltage comparators. The AD96685 is a single comparator with 2.5ns propagation delay; the AD96687 is an equally fast dual comparator. Both devices feature 50ps propagation delay dispersion which is a particularly important characteristic of high speed comparators. It is a measure of the difference in propagation delay under differing overdrive conditions.

A fast, high precision differential input stage permits consistent propagation delay with a wide variety of signals in the common-mode range from -2.5V to +5V. Outputs are complementary digital signals fully compatible with ECL 10K and 10KH logic families. The outputs provide sufficient drive current to directly drive transmission lines terminated in 50Ω to -2V. A level-sensitive latch input is included which permits tracking, track-hold, or sample-hold modes of operation.

#### AD96685 FUNCTIONAL BLOCK DIAGRAM



#### AD96687 FUNCTIONAL BLOCK DIAGRAM



THE OUTPUTS ARE OPEN EMITTERS, REQUIRING EXTERNAL PULL-DOWN RESISTORS. THESE RESISTORS MAY BE IN THE RANGE OF 50Ω - 200Ω CONNECTED TO -2.0V, OR 200Ω - 2000Ω

The AD96685 and AD96687 are available in both industrial, -25°C to +85°C, and military temperature ranges. Industrial range devices are available in 16-pin DIP, SOIC, and 20-lead PLCC; additionally, the AD96685 is available in a 10-pin, TO-100 metal can. Both devices are available qualified to MIL-STD-883, Class B in 16-pin ceramic DIP and 20-lead ceramic LCC; the TO-100 version of the AD96685 is also mil-qualified.

# AD96685/AD96687—SPECIFICATIONS

T-73-53

## ABSOLUTE MAXIMUM RATINGS<sup>1</sup>

Positive Supply Voltage (+V <sub>S</sub> )	..... +6.5V	Operating Temperature Range <sup>3</sup>	AD96685/87/BH/BQ/BP/BR	..... -25°C to +85°C
Negative Supply Voltage (-V <sub>S</sub> )	..... -6.5V		AD96685/87/TE/TH/TQ	..... -55°C to +125°C
Input Voltage Range <sup>2</sup>	..... ±5V	Storage Temperature Range	..... -55°C to +150°C	
Differential Input Voltage	..... 5.5V	Junction Temperature	..... +175°C	
Latch Enable Voltage	..... -V <sub>S</sub> to 0V	Lead Soldering Temperature (10sec)	..... +300°C	
Output Current	..... 30mA			

## ELECTRICAL CHARACTERISTICS (Positive Supply Voltage = +5.0V; Negative Supply Voltage = -5.2V, unless otherwise stated)

Parameter	Temp	Test Level	Industrial Temp. Range -25°C to +85°C						Extended Temp. Range -55°C to +125°C						Units
			AD96685BH/BQ/BP/BR			AD96687BQ/BP/BR			AD96685TE/TH/TQ			AD96687TE/TQ			
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
<b>INPUT CHARACTERISTICS</b>															
Input Offset Voltage <sup>4</sup>	+25°C	I	1	2		1	2		1	2		1	2	mV	
	Full	VI		3			3			3			3	mV	
Input Offset Drift	Full	V							20				20	μV/°C	
Input Bias Current	+25°C	I	7	10		7	10		7	10		7	10	μA	
	Full	VI		13			13			16			16	μA	
Input Offset Current	+25°C	I	0.1	1.0		0.1	1.0		0.1	1.0		0.1	1.0	μA	
	Full	VI		1.2			1.2			1.2			1.2	μA	
Input Resistance	+25°C	V		200			200			200			200	kΩ	
Input Capacitance	+25°C	V		2			2			2			2	pF	
Input Voltage Range <sup>5</sup>	Full	VI	-2.5		+5.0	-2.5		+5.0	-2.5		+5.0	-2.5		+5.0	V
Common-Mode Rejection Ratio	Full	VI	80	90		80	90		80	90		80	90	dB	
<b>ENABLE INPUT</b>															
Logic "1" Voltage	Full	VI	-1.1			-1.1			-1.1			-1.1		V	
Logic "0" Voltage	Full	VI		-1.5			-1.5			-1.5			-1.5	V	
Logic "1" Current	Full	VI		40			40			40			40	μA	
Logic "0" Current	Full	VI		5			5			5			5	μA	
<b>DIGITAL OUTPUTS<sup>6</sup></b>															
Logic "1" Voltage	Full	VI	-1.1			-1.1			-1.1			-1.1		V	
Logic "0" Voltage	Full	VI		-1.5			-1.5			-1.5			-1.5	V	
<b>SWITCHING PERFORMANCE<sup>6</sup></b>															
Propagation Delays <sup>7</sup>															
Input to Output HIGH	+25°C	IV		2.5	3.5		2.5	3.5		2.5	3.5		2.5	3.5	ns
Input to Output LOW	+25°C	IV		2.5	3.5		2.5	3.5		2.5	3.5		2.5	3.5	ns
Latch Enable to Output HIGH	+25°C	IV		2.5	3.5		2.5	3.5		2.5	3.5		2.5	3.5	ns
Latch Enable to Output LOW	+25°C	IV		2.5	3.5		2.5	3.5		2.5	3.5		2.5	3.5	ns
Dispersion <sup>8</sup>	+25°C	V		50			50			50			50	ps	
Latch Enable															
Minimum Pulse Width	+25°C	IV		2.0	3.0		2.0	3.0		2.0	3.0		2.0	3.0	ns
Minimum Setup Time	+25°C	IV		0.5	1.0		0.5	1.0		0.5	1.0		0.5	1.0	ns
Minimum Hold Time	+25°C	IV		0.5	1.0		0.5	1.0		0.5	1.0		0.5	1.0	ns
<b>POWER SUPPLY<sup>9</sup></b>															
Positive Supply Current (+5.0V)	Full	VI		8	9		15	18		8	9		15	18	mA
Negative Supply Current (-5.2V)	Full	VI		15	18		31	36		15	18		31	36	mA
Power Supply Rejection Ratio <sup>10</sup>	Full	VI	60	70		60	70		60	70		60	70	dB	

**NOTES**

<sup>1</sup>Absolute maximum ratings are limiting values, to be applied individually, and beyond which serviceability of the circuit may be impaired. Functional operation under any of these conditions is not necessarily implied.

Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

<sup>2</sup>Under no circumstances should the input voltages exceed the supply voltages.

<sup>3</sup>Typical thermal impedances . . .

AD96685 Metal Can	θ <sub>JA</sub> = 172°C/W; θ <sub>JC</sub> = 52°C/W
AD96685 Ceramic	θ <sub>JA</sub> = 115°C/W; θ <sub>JC</sub> = 57°C/W
AD96685 LCC	θ <sub>JA</sub> = 172°C/W; θ <sub>JC</sub> = 65°C/W
AD96685 SOIC	θ <sub>JA</sub> = 170°C/W; θ <sub>JC</sub> = 60°C/W
AD96685 PLCC	θ <sub>JA</sub> = 88°C/W; θ <sub>JC</sub> = 45°C/W
AD96687 Ceramic	θ <sub>JA</sub> = 115°C/W; θ <sub>JC</sub> = 57°C/W
AD96687 LCC	θ <sub>JA</sub> = 82°C/W; θ <sub>JC</sub> = 31°C/W
AD96687 SOIC	θ <sub>JA</sub> = 92°C/W; θ <sub>JC</sub> = 47°C/W
AD96687 PLCC	θ <sub>JA</sub> = 81°C/W; θ <sub>JC</sub> = 45°C/W

<sup>4</sup>R<sub>S</sub> = 100Ω.

<sup>5</sup>Input Voltage Range can be extended to -3.3V if -V<sub>S</sub> = -6.0V.

<sup>6</sup>Outputs terminated through 50Ω to -2.0V.

<sup>7</sup>Propagation delays measured with 100mV pulse (10mV overdrive), to 50% transition point of the output.

<sup>8</sup>Change in propagation Delay from 100mV to 1V input overdrive.

<sup>9</sup>Supply voltages should remain stable within ±5% for normal operation.

<sup>10</sup>Measured at ±5% of +V<sub>S</sub> and -V<sub>S</sub>.

Specifications subject to change without notice.

### EXPLANATION OF TEST LEVELS

#### Test Level

- I - 100% production tested.
- II - 100% production tested at +25°C, and sample tested at specified temperatures.
- III - Sample tested only.
- IV - Parameter is guaranteed by design and characterization testing.
- V - Parameter is a typical value only.
- VI - All devices are 100% production tested at +25°C; 100% production tested at temperature extremes for extended temperature devices; sample tested at temperature extremes for commercial/industrial devices.

**AD96685/AD96687**

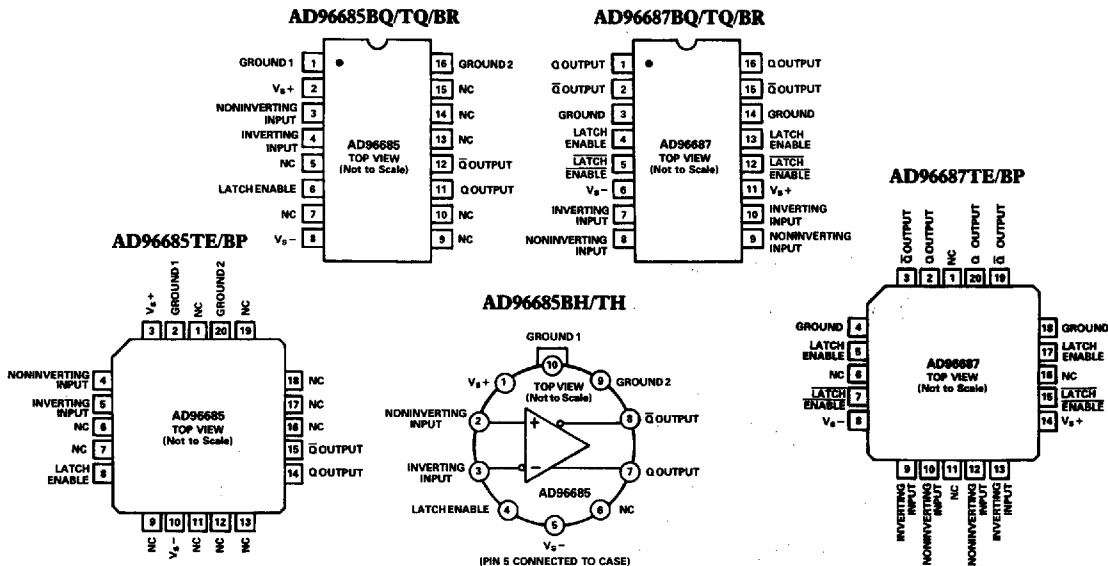
**FUNCTIONAL DESCRIPTION**

**T-73-53**

Pin Name	Description
$+V_S$	- Positive supply terminal, nominally +5.0V.
NONINVERTING INPUT	- Noninverting analog input of the differential input stage. The NONINVERTING INPUT must be driven in conjunction with the INVERTING INPUT.
INVERTING INPUT	- Inverting analog input of the differential input stage. The INVERTING INPUT must be driven in conjunction with the NONINVERTING INPUT.
LATCH ENABLE	- In the "compare" mode (logic HIGH), the output will track changes at the input of the comparator. In the "latch" mode (logic LOW), the output will reflect the input state just prior to the comparator being placed in the "latch" mode. LATCH ENABLE must be driven in conjunction with LATCH ENABLE for the AD96687.
LATCH ENABLE	- In the "compare" mode (logic LOW), the output will track changes at the input of the comparator. In the "latch" mode (logic HIGH), the output will reflect the input state just prior to the comparator being placed in the "latch" mode. LATCH ENABLE must be driven in conjunction with LATCH ENABLE for the AD96687.
$-V_S$	- Negative supply terminal, nominally -5.2V.
Q	- One of two complementary outputs. Q will be at logic HIGH if the analog voltage at the NONINVERTING INPUT is greater than the analog voltage at the INVERTING INPUT (provided the comparator is in the "compare" mode). See LATCH ENABLE and LATCH ENABLE (AD96687 only) for additional information.
$\bar{Q}$	- One of two complementary outputs. $\bar{Q}$ will be at logic LOW if the analog voltage at the NONINVERTING INPUT is greater than the analog voltage at the INVERTING INPUT (provided the comparator is in the "compare" mode). See LATCH ENABLE and LATCH ENABLE (AD96687 only) for additional information.
GROUND 1	- One of two grounds, but primarily associated with the digital ground. Both grounds should be connected together near the comparator.
GROUND 2	- One of two grounds, but primarily associated with the analog ground. Both grounds should be connected together near the comparator.

3

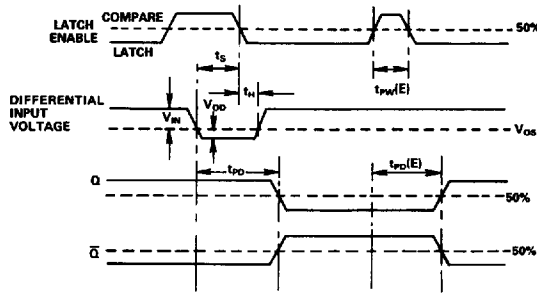
**PIN DESIGNATIONS**



**AD96685/AD96687**

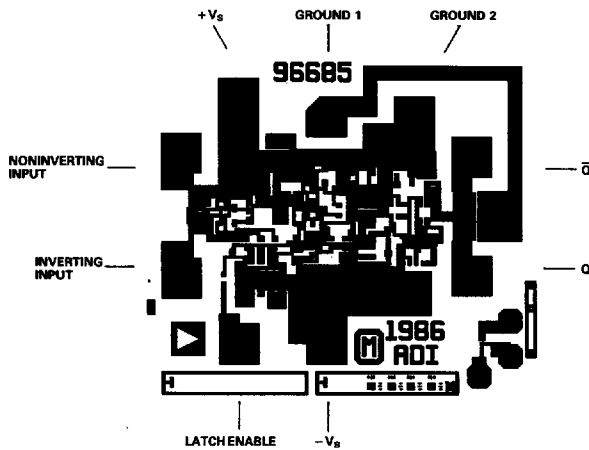
**SYSTEM TIMING DIAGRAM**

T-73-53

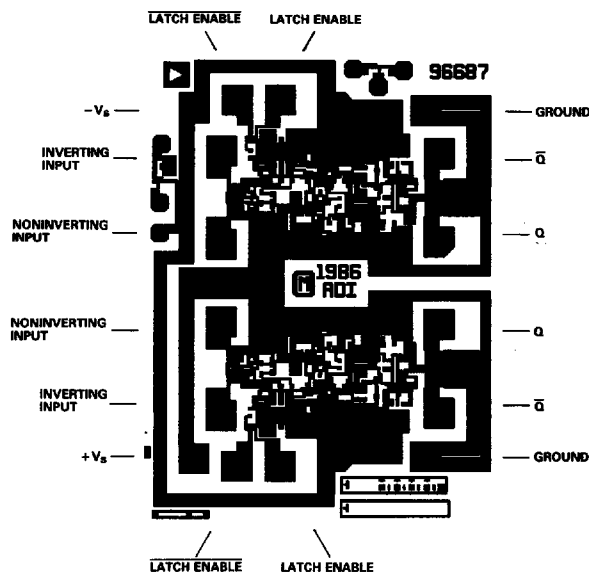


- $t_S$  - Minimum Setup Time
- $t_H$  - Minimum Hold Time
- $t_{PD}$  - Input to Output Delay
- $t_{PD}(E)$  - LATCH ENABLE to Output Delay
- $t_{PW}(E)$  - Minimum LATCH ENABLE Pulse Width
- $V_{OS}$  - Input Offset Voltage
- $V_{OD}$  - Overdrive Voltage

**DIE LAYOUT AND MECHANICAL INFORMATION**



Die Dimensions	AD96685	44 × 50 × 15 (±2) mils
Pad Dimensions		4 × 4 mils
Metalization		Aluminum
Backing		None
Substrate Potential		$-V_S$
Passivation		Oxynitride
Die Attach		Gold Eutectic
Bond Wire		1.25 mil, Aluminum; Ultrasonic Bonding or 1mil, Gold, Gold Ball Bonding



Die Dimensions	AD96687	77 × 60 × 15 (±2) mils
Pad Dimensions		4 × 4 mils
Metalization		Aluminum
Backing		None
Substrate Potential		$-V_S$
Passivation		Oxynitride
Die Attach		Gold Eutectic
Bond Wire		1.25 mil, Aluminum; Ultrasonic Bonding or 1mil, Gold, Gold Ball Bonding

## AD96685/AD96687

## ORDERING GUIDE

T-73-53

Device	Type	Temperature Range	Description	Package Options*
AD96685BH	Single	-25°C to +85°C	10-Pin Can, Industrial	H-10A
AD96685BP	Single	-25°C to +85°C	20-Pin PLCC, Industrial	P-20A
AD96685BQ	Single	-25°C to +85°C	16-Pin DIP, Industrial	Q-16
AD96685BR	Single	-25°C to +85°C	16-Pin SOIC, Industrial	R-16
AD96685TE	Single	-55°C to +125°C	20-Pin LCC, Extended Temperature	E-20A
AD96685TH	Single	-55°C to +125°C	10-Pin Can, Extended Temperature	H-10A
AD96685TQ	Single	-55°C to +125°C	16-Pin DIP, Extended Temperature	Q-16
AD96687BP	Dual	-25°C to +85°C	20-Pin PLCC, Industrial	P-20A
AD96687BQ	Dual	-25°C to +85°C	16-Pin DIP, Industrial	Q-16
AD96687BR	Dual	-25°C to +85°C	16-Pin SOIC, Industrial	R-16
AD96687TE	Dual	-55°C to +125°C	20-Pin LCC, Extended Temperature	E-20A
AD96687TQ	Dual	-55°C to +125°C	16-Pin DIP, Extended Temperature	Q-16

\*For outline information see Package Information section.

## APPLICATIONS INFORMATION

The AD96685/87 comparators are very high speed devices. Consequently, high speed design techniques must be employed to achieve the best performance. The most critical aspect of any AD96685/87 design is the use of a low impedance ground plane.

Another area of particular importance is power supply decoupling. Normally, both power supply connections should be separately decoupled to ground through 0.1 $\mu$ F ceramic and 0.001 $\mu$ F mica capacitors. The basic design of comparator circuits makes the negative supply somewhat more sensitive to variations. As a result more attention should be placed on insuring a "clean" negative supply.

The LATCH ENABLE input is active LOW (latched). If the latching function is not used, the LATCH ENABLE input should be grounded (ground is an ECL logic HIGH). The LATCH ENABLE input of the AD96687 should be tied to -2.0V or left "floating," to disable the latching function. An alternate use of the LATCH ENABLE input is as a hysteresis control input. By varying the voltage at the LATCH ENABLE input for the AD96685 and the differential voltage between both latch inputs for the AD96687, small variations in the hysteresis can be achieved.

Occasionally, one of the two comparator stages within the AD96687 will not be used. The inputs of the unused comparator should not be allowed to "float." The high internal gain may cause the output to oscillate (possibly affecting the other comparator which is being used) unless the output is forced into a fixed state. This is easily accomplished by insuring that the two inputs are at least one diode drop apart, while also grounding the LATCH ENABLE input.

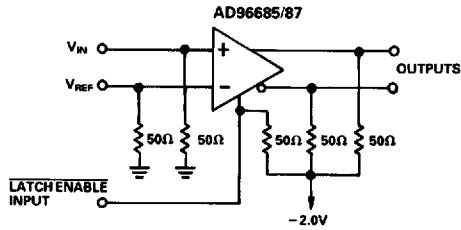
The best performance will be achieved with the use of proper ECL terminations. The open-emitter outputs of the AD96685/87 are designed to be terminated through 50 $\Omega$  resistors to -2.0V, or any other equivalent ECL termination. If high speed ECL signals must be routed more than a few centimeters, MicroStrip or StripLine techniques may be required to insure proper transition times and prevent output ringing.

The AD96685/87 have been specifically designed to reduce propagation delay dispersion over an input overdrive range of 100mV to 1V. Propagation delay dispersion is the change in propagation delay which results from a change in the degree of overdrive (how far the switching point is exceeded by the input). The overall result is a higher degree of timing accuracy since the AD96685/87 is far less sensitive to input variations than most comparator designs.

## AD96685/AD96687—Typical Applications

T-73-53

## HIGH SPEED SAMPLING CIRCUIT



## HIGH SPEED WINDOW COMPARATOR

