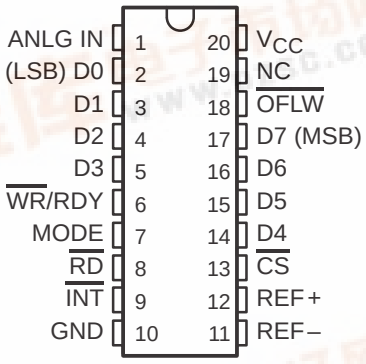
Advanced LinCMOS™ HIGH-SPEED 8-BIT ANALOG-TO-DIGITAL CONVERTERS USING MODIFIED FLASH TECHNIQUES

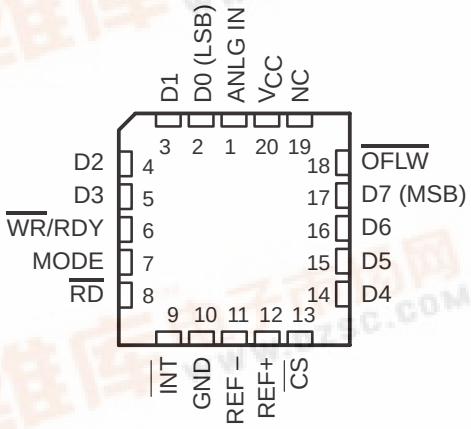
SLAS064A – SEPTEMBER 1986 – REVISED JUNE 1994

- **Advanced LinCMOS™ Silicon-Gate Technology**
- **8-Bit Resolution**
- **Differential Reference Inputs**
- **Parallel Microprocessor Interface**
- **Conversion and Access Time Over Temperature Range**
  Read Mode . . . 2.5 μs Max
- **No External Clock or Oscillator Components Required**
- **On-Chip Track and Hold**
- **Single 5-V Supply**
- **TLC0820A Is Direct Replacement for National Semiconductor ADC0820C/CC and Analog Devices AD7820K/B/T**

DB, DW, OR N PACKAGE
(TOP VIEW)



FN PACKAGE
(TOP VIEW)



NC – No internal connection

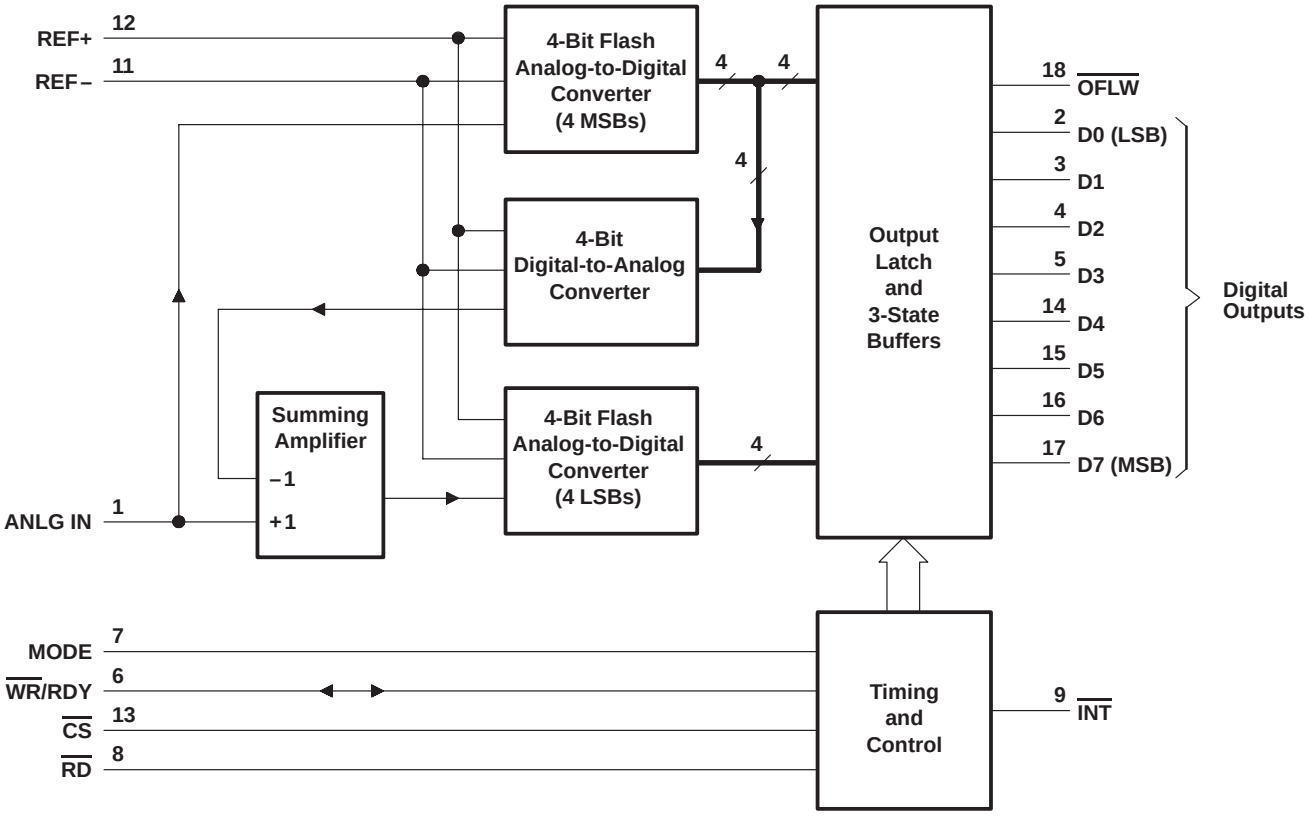
description

The TLC0820AC and the TLC0820AI are Advanced LinCMOS™ 8-bit analog-to-digital converters each consisting of two 4-bit flash converters, a 4-bit digital-to-analog converter, a summing (error) amplifier, control logic, and a result latch circuit. The modified flash technique allows low-power integrated circuitry to complete an 8-bit conversion in 1.18 μs over temperature. The on-chip track-and-hold circuit has a 100-ns sample window and allows these devices to convert continuous analog signals having slew rates of up to 100 mV/μs without external sampling components. TTL-compatible 3-state output drivers and two modes of operation allow interfacing to a variety of microprocessors. Detailed information on interfacing to most popular microprocessors is readily available from the factory.

AVAILABLE OPTIONS

T_A	TOTAL UNADJUSTED ERROR	PACKAGE			
		SSOP (DB)	PLASTIC SMALL OUTLINE (DW)	PLASTIC CHIP CARRIER (FN)	PLASTIC DIP (N)
0°C to 70°C	±1 LSB	TLC0820ACDB	TLC0820ACDW	TLC0820ACFN	TLC0820ACN
–40°C to 85°C	±1 LSB	—	TLC0820AIDW	TLC0820AIFN	TLC0820AIN

functional block diagram



Terminal Functions

TERMINAL NAME	TERMINAL NO.	I/O	DESCRIPTION
ANLG IN	1	I	Analog input
$\overline{CS}$	13	I	Chip select. $\overline{CS}$ must be low in order for $\overline{RD}$ or $\overline{WR}$ to be recognized by the ADC.
D0	2	O	Digital, 3-state output data, bit 1 (LSB)
D1	3	O	Digital, 3-state output data, bit 2
D2	4	O	Digital, 3-state output data, bit 3
D3	5	O	Digital, 3-state output data, bit 4
D4	14	O	Digital, 3-state output data, bit 5
D5	15	O	Digital, 3-state output data, bit 6
D6	16	O	Digital, 3-state output data, bit 7
D7	17	O	Digital, 3-state output data, bit 8 (MSB)
GND	10		Ground
$\overline{INT}$	9	O	Interrupt. In the write-read mode, the interrupt output ($\overline{INT}$) going low indicates that the internal count-down delay time, $t_{d(int)}$, is complete and the data result is in the output latch. The delay time $t_{d(int)}$ is typically 800 ns starting after the rising edge of $\overline{WR}$ (see operating characteristics and Figure 3). If $\overline{RD}$ goes low prior to the end of $t_{d(int)}$, $\overline{INT}$ goes low at the end of $t_{d(RIL)}$ and the conversion results are available sooner (see Figure 2). $\overline{INT}$ is reset by the rising edge of either $\overline{RD}$ or $\overline{CS}$.
MODE	7	I	Mode select. MODE is internally tied to GND through a 50-μA current source, which acts like a pulldown resistor. When MODE is low, the read mode is selected. When MODE is high, the write-read mode is selected.
NC	19		No internal connection
$\overline{OFLW}$	18	O	Overflow. Normally $\overline{OFLW}$ is a logical high. However, if the analog input is higher than V_{ref+}, $\overline{OFLW}$ will be low at the end of conversion. It can be used to cascade two or more devices to improve resolution (9 or 10 bits).
$\overline{RD}$	8	I	Read. In the write-read mode with $\overline{CS}$ low, the 3-state data outputs D0 through D7 are activated when $\overline{RD}$ goes low. $\overline{RD}$ can also be used to increase the conversion speed by reading data prior to the end of the internal count-down delay time. As a result, the data transferred to the output latch is latched after the falling edge of $\overline{RD}$. In the read mode with $\overline{CS}$ low, the conversion starts with $\overline{RD}$ going low. $\overline{RD}$ also enables the 3-state data outputs on completion of the conversion. RDY going into the high-impedance state and $\overline{INT}$ going low indicate completion of the conversion.
REF–	11	I	Reference voltage. REF– is placed on the bottom of the resistor ladder.
REF+	12	I	Reference voltage. REF+ is placed on the top of the resistor ladder.
V_{CC}	20		Power supply voltage
$\overline{WR}$/RDY	6	I/O	Write ready. In the write-read mode with $\overline{CS}$ low, the conversion is started on the falling edge of the $\overline{WR}$ input signal. The result of the conversion is strobed into the output latch after the internal count-down delay time, $t_{d(int)}$, provided that the $\overline{RD}$ input does not go low prior to this time. The delay time $t_{d(int)}$ is approximately 800 ns. In the read mode, RDY (an open-drain output) goes low after the falling edge of $\overline{CS}$ and goes into the high-impedance state when the conversion is strobed into the output latch. It is used to simplify the interface to a microprocessor system.

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage, V_{CC} (see Note 1) . . . . . 10 V
Input voltage range, all inputs (see Note 1) . . . . . –0.2 V to V_{CC}+0.2 V
Output voltage range, all outputs (see Note 1) . . . . . –0.2 V to V_{CC}+0.2 V
Operating free-air temperature range: TLC0820AC . . . . . 0°C to 70°C
TLC0820AI . . . . . –40°C to 85°C
Storage temperature range . . . . . –65°C to 150°C
Case temperature for 10 seconds: FN package . . . . . 260°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: DB, DW or N package . . . . . 260°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTE 1: All voltages are with respect to network GND.

recommended operating conditions

			MIN	NOM	MAX	UNIT
Supply voltage, V_{CC}			4.5	5	8	V
Analog input voltage			–0.1		V_{CC}+0.1	V
Positive reference voltage, V_{ref+}			V_{ref-}		V_{CC}	V
Negative reference voltage, V_{ref-}			GND		V_{ref+}	V
High-level input voltage, V_{IH}	V_{CC} = 4.75 V to 5.25 V	$\overline{CS}$, $\overline{WR}$/RDY, $\overline{RD}$	2			V
		MODE	3.5			
Low-level input voltage, V_{IL}	V_{CC} = 4.75 V to 5.25 V	$\overline{CS}$, $\overline{WR}$/RDY, $\overline{RD}$			0.8	V
		MODE			1.5	
Pulse duration, write in write-read mode, $t_{w(W)}$ (see Figures 2, 3, and 4)			0.5		50	µs
Operating free-air temperature, T_A	TLC0820AC		0		70	°C
	TLC0820AI		–40		85	

electrical characteristics at specified operating free-air temperature, V_{CC} = 5 V (unless otherwise noted)

PARAMETER			TEST CONDITIONS	T_A†	MIN	TYP	MAX	UNIT
V_{OH}	High-level output voltage	D0–D7, INT, or OFLW	V_{CC} = 4.75 V, I_{OH} = –360 µA	Full range	2.4			V
			V_{CC} = 4.75 V, I_{OH} = –10 µA	Full range	4.5			
				25°C	4.6			
V_{OL}	Low-level output voltage	D0–D7, OFLW, INT, or WR/RDY	V_{CC} = 5.25 V, I_{OL} = 1.6 mA	Full range			0.4	V
				25°C			0.34	
I_{IH}	High-level input current	CS or RD	V_{IH} = 5 V	Full range		0.005	1	µA
		WR/RDY		Full range			3	
				25°C		0.1	0.3	
		MODE		Full range			200	
				25°C		50	170	
I_{IL}	Low-level input current	CS, WR/RDY, RD, or MODE	V_{IL} = 0	Full range		–0.005	–1	µA
I_{OZ}	Off-state (high-impedance-state) output current	D0–D7 or WR/RDY	V_O = 5 V	Full range			3	µA
				25°C		0.1	0.3	
			V_O = 0	Full range			–3	
				25°C		–0.1	–0.3	
I_I	Analog input current		CS at 5 V, V_I = 5 V	Full range			3	µA
				25°C			0.3	
			CS at 5 V, V_I = 0	Full range			–3	
				25°C			–0.3	
I_{OS}	Short-circuit output current	D0–D7, OFLW, INT, or WR/RDY	V_O = 5 V	Full range	7			mA
				25°C	8.4	14		
		D0–D7 or OFLW	V_O = 0	Full range	–6			
				25°C	–7.2	–12		
		INT		Full range	–4.5			
				25°C	– 5.3	–9		
R_{ref}	Reference resistance			Full range	1.25		6	kΩ
				25°C	1.4	2.3	5.3	
I_{CC}	Supply current		CS, WR/RDY, and RD at 0 V	Full range			15	mA
				25°C		7.5	13	
C_i	Input capacitance	D0–D7		Full range		5		pF
		ANLG IN				45		
C_o	Output capacitance	D0–D7		Full range			5	pF

† Full range is as specified in recommended operating conditions.

operating characteristics, V_{CC} = 5 V, V_{ref+} = 5 V, V_{ref-} = 0, $t_r = t_f$ = 20 ns, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS†		MIN	TYP	MAX	UNIT
k_{SVS}	Supply-voltage sensitivity	V_{CC} = 5 V ± 5%,	T_A = MIN to MAX		±1/16	±1/4	LSB
	Total unadjusted error‡	MODE at 0 V,	T_A = MIN to MAX			1	LSB
$t_{conv(R)}$	Conversion time, read mode	MODE at 0 V,	See Figure 1		1.6	2.5	µs
$t_{a(R)}$	Access time, $\overline{RD}$↓ to data valid	MODE at 0 V,	See Figure 1		$t_{conv(R)}$ +20	$t_{conv(R)}$ +50	ns
$t_{a(R1)}$	Access time, $\overline{RD}$↓ to data valid	MODE at 5 V, $t_{d(WR)} < t_{d(int)}$, See Figure 2	C_L = 15 pF		190	280	ns
			C_L = 100 pF		210	320	
$t_{a(R2)}$	Access time, $\overline{RD}$↓ to data valid	MODE at 5 V, $t_{d(WR)} > t_{d(int)}$, See Figure 3	C_L = 15 pF		70	120	ns
			C_L = 100 pF		90	150	
$t_{a(INT)}$	Access time, $\overline{INT}$↓ to data valid	MODE at 5 V,	See Figure 4		20	50	ns
t_{dis}	Disable time, $\overline{RD}$↑ to data valid	R_L = 1 kΩ, See Figures 1, 2, 3, and 5	C_L = 10 pF,		70	95	ns
$t_{d(int)}$	Delay time, WR/RDY↑ to INT↓	MODE at 5 V, See Figures 2, 3, and 4	C_L = 50 pF,		800	1300	ns
$t_{d(NC)}$	Delay time, to next conversion	See Figures 1, 2, 3, and 4		500			ns
$t_{d(WR)}$	Delay time, $\overline{WR}$/RDY↑ to $\overline{RD}$↓ in write-read mode	See Figure 2		0.4			µs
$t_{d(RDY)}$	Delay time, CS↓ to WR/RDY↓	MODE at 0 V, See Figure 1	C_L = 50 pF,		50	100	ns
$t_{d(RIH)}$	Delay time, $\overline{RD}$↑ to $\overline{INT}$↑	C_L = 50 pF,	See Figures 1, 2, and 3		125	225	ns
$t_{d(RIL)}$	Delay time, RD↓ to INT↓	MODE at 5 V, See Figure 2	$t_{d(WR)} < t_{d(int)}$,		200	290	ns
$t_{d(WIH)}$	Delay time, $\overline{WR}$/RDY↑ to $\overline{INT}$↑	MODE at 5 V, See Figure 4	C_L = 50 pF,		175	270	ns
	Slew-rate tracking				0.1		V/µs

† For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.
‡ Total unadjusted error includes offset, full-scale, and linearity errors.

PARAMETER MEASUREMENT INFORMATION

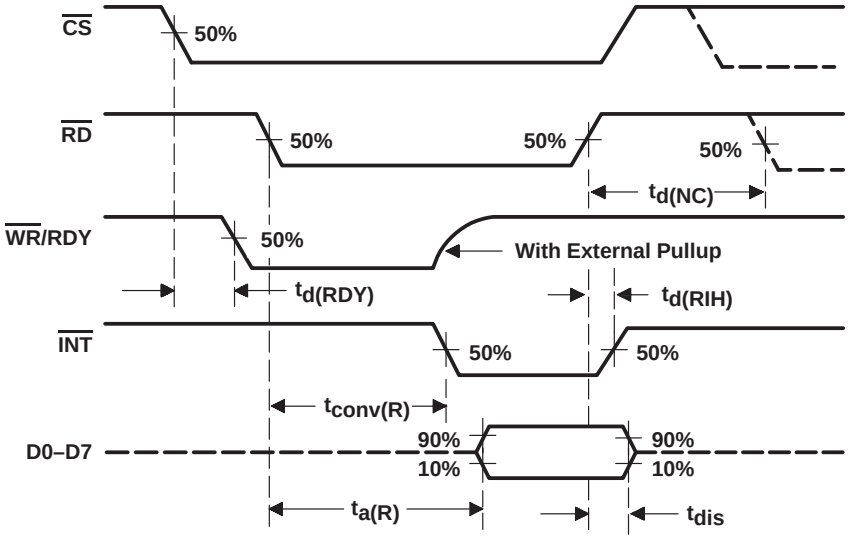


Figure 1. Read-Mode Waveforms (MODE Low)

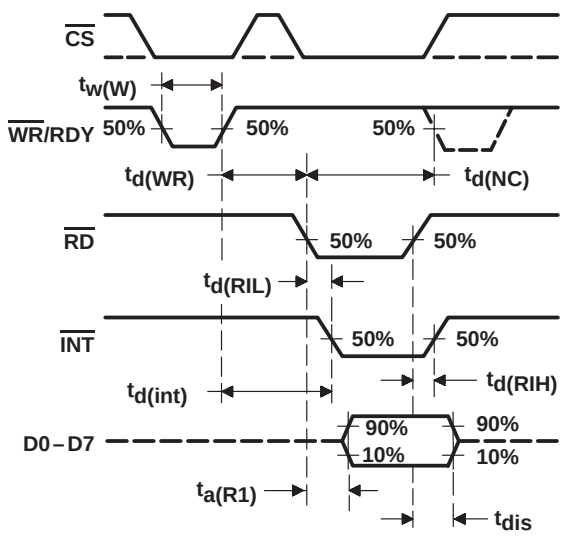


Figure 2. Write-Read-Mode Waveforms [MODE High and $t_{d(WR)} < t_{d(int)}$]

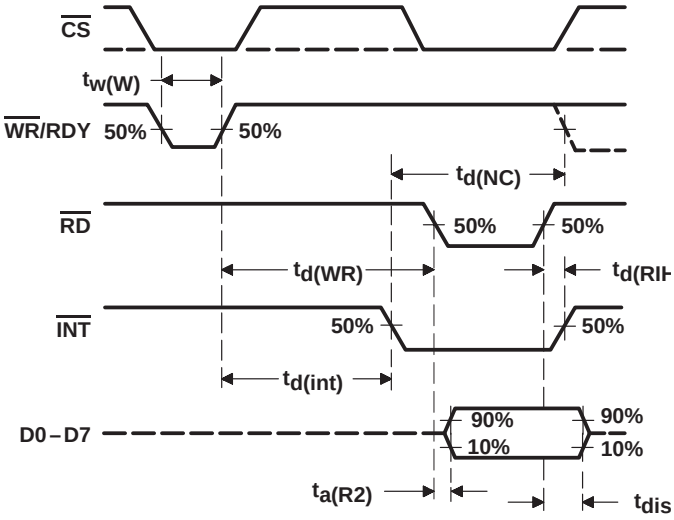


Figure 3. Write-Read-Mode Waveforms [MODE High and $t_{d(WR)} > t_{d(int)}$]

PARAMETER MEASUREMENT INFORMATION

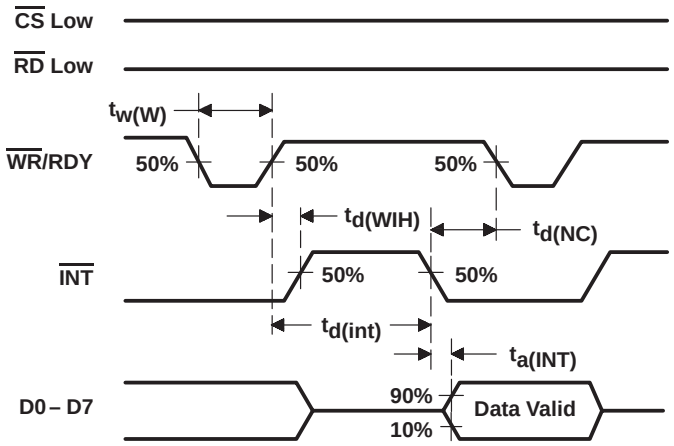


Figure 4. Write-Read-Mode Waveforms (Stand-Alone Operation, MODE High, and RD Low)

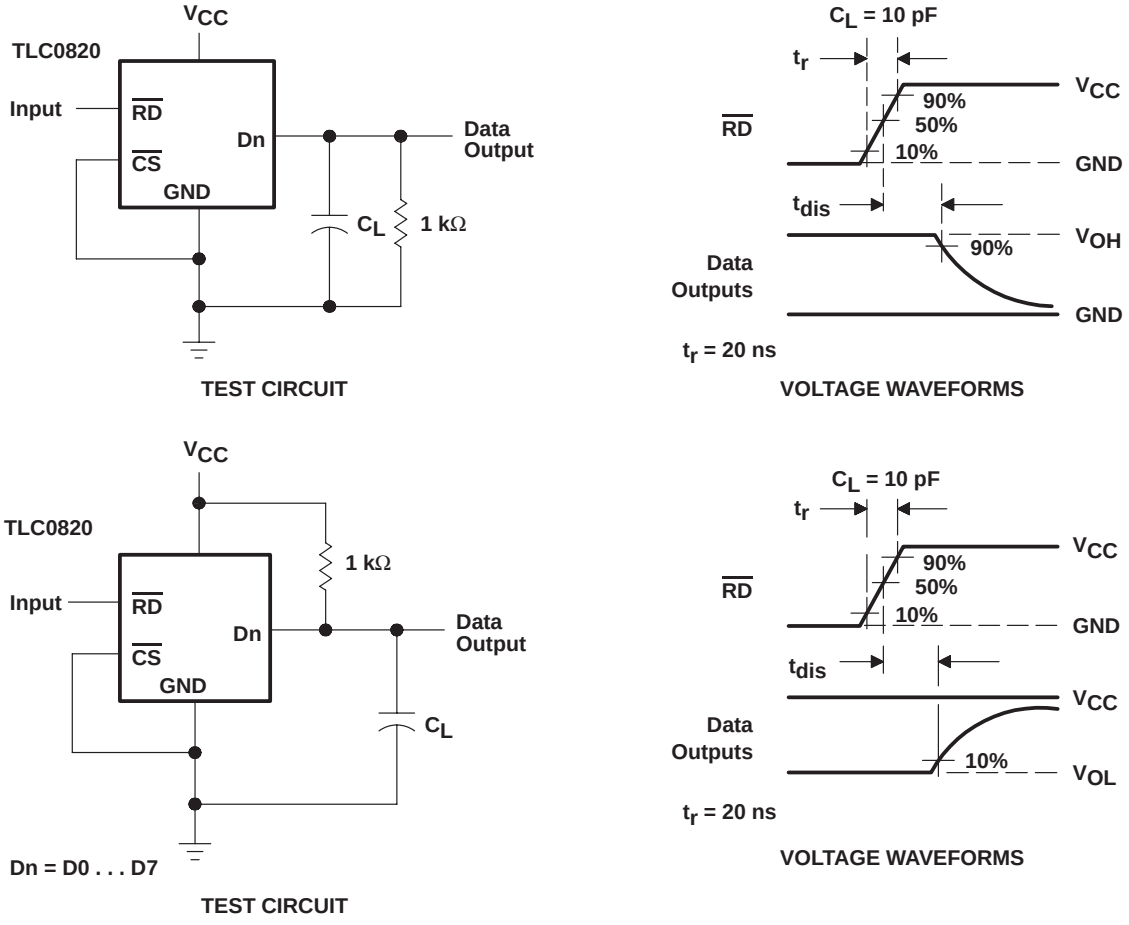


Figure 5. Test Circuit and Voltage Waveforms

PRINCIPLES OF OPERATION

The TLC0820AC and TLC0820AI each employ a combination of sampled-data comparator techniques and flash techniques common to many high-speed converters. Two 4-bit flash analog-to-digital conversions are used to give a full 8-bit output.

The recommended analog input voltage range for conversion is –0.1 V to V_{CC} + 0.1 V. Analog input signals that are less than V_{ref-} + 1/2 LSB or greater than V_{ref+} – 1/2 LSB convert to 00000000 or 11111111, respectively. The reference inputs are fully differential with common-mode limits defined by the supply rails. The reference input values define the full-scale range of the analog input. This allows the gain of the ADC to be varied for ratiometric conversion by changing the V_{ref+} and V_{ref-} voltages.

The device operates in two modes, read (only) and write-read, that are selected by MODE. The converter is set to the read (only) mode when MODE is low. In the read mode, $\overline{WR}$/RDY is used as an output and is referred to as the ready terminal. In this mode, a low on $\overline{WR}$/RDY while $\overline{CS}$ is low indicates that the device is busy. Conversion starts on the falling edge of $\overline{RD}$ and is completed no more than 2.5 μs later when $\overline{INT}$ falls and $\overline{WR}$/RDY returns to the high-impedance state. Data outputs also change from high-impedance to active states at this time. After the data is read, $\overline{RD}$ is taken high, $\overline{INT}$ returns high, and the data outputs return to their high-impedance states.

When MODE is high, the converter is set to the write-read mode and $\overline{WR}$/RDY is referred to as the write terminal. Taking $\overline{CS}$ and $\overline{WR}$/RDY low selects the converter and initiates measurement of the input signal. Approximately 600 ns after $\overline{WR}$/RDY returns high, the conversion is completed. Conversion starts on the rising edge of $\overline{WR}$/RDY in the write-read mode.

The high-order 4-bit flash ADC measures the input by means of 16 comparators operating simultaneously. A high-precision 4-bit DAC then generates a discrete analog voltage from the result of that conversion. After a time delay, a second bank of comparators does a low-order conversion on the analog difference between the input level and the high-order DAC output. The results from each of these conversions enter an 8-bit latch and are output to the 3-state output buffers on the falling edge of $\overline{RD}$.

APPLICATION INFORMATION

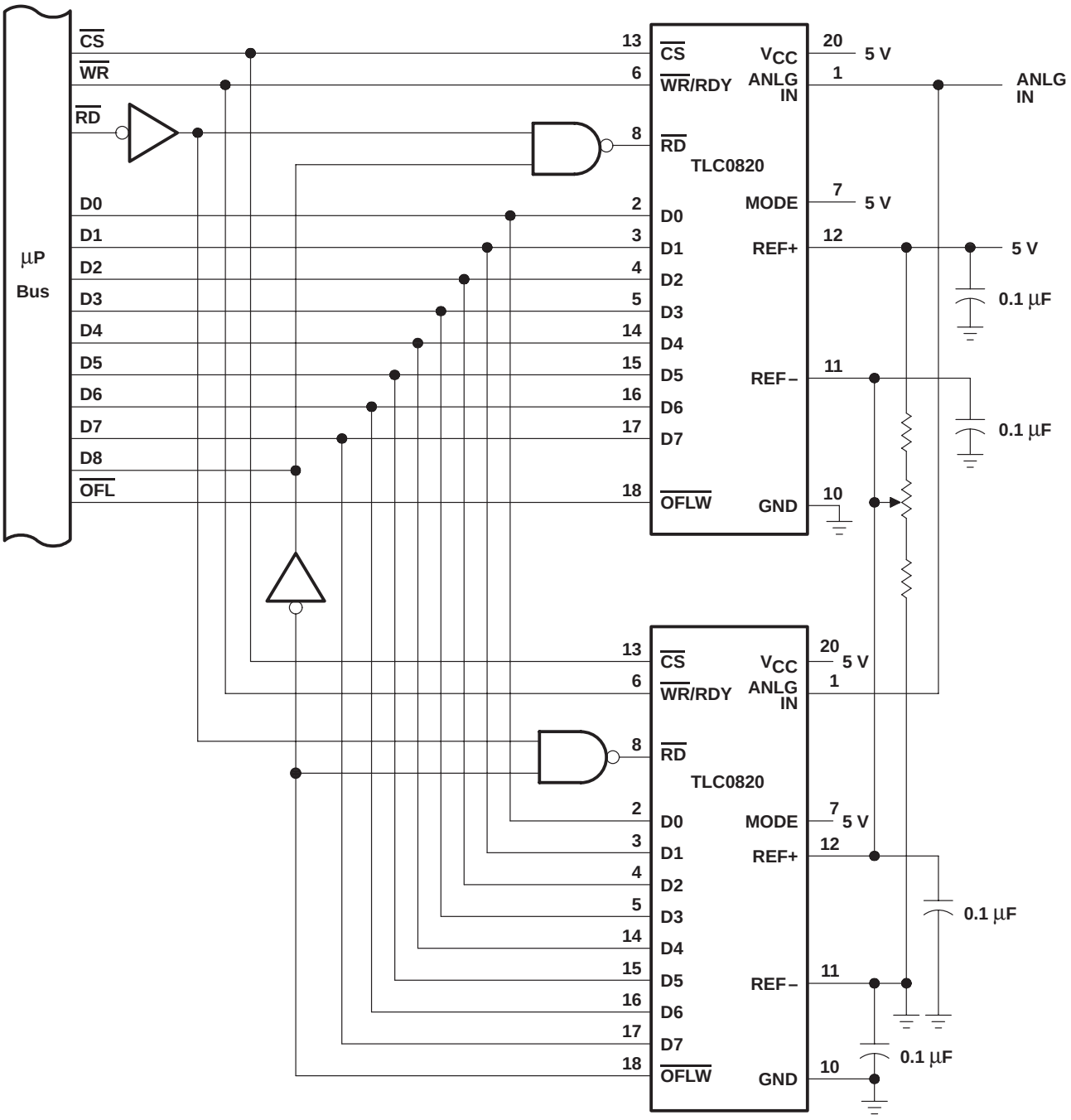


Figure 6. Configuration for 9-Bit Resolution

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