

TLC0820A, TLC0820B, ADC0820B, ADC0820C Advanced LinCMOS™ HIGH-SPEED 8-BIT ANALOG-TO-DIGITAL CONVERTERS USING MODIFIED "FLASH" TECHNIQUES

D2873, SEPTEMBER 1986—REVISED FEBRUARY 1989

- Advanced LinCMOS™ Silicon-Gate Technology
- 8-Bit Resolution
- Differential Reference Inputs
- Parallel Microprocessor Interface
- Conversion and Access Time Over Temperature Range
Write-Read Mode . . . 1.18 μ s and 1.92 μ s
Read Mode . . . 2.5 μ s Max
- No External Clock or Oscillator Components Required
- On-Chip Track-and-Hold
- Low Power Consumption . . . 50 mW Typ
- Single 5-V Supply
- TLC0820B is Direct Replacement for National Semiconductor ADC0820B/BC and Analog Devices AD7820L/C/U;
TLC0820A is Direct Replacement for National Semiconductor ADC0820C/CC and Analog Devices AD7820K/B/T

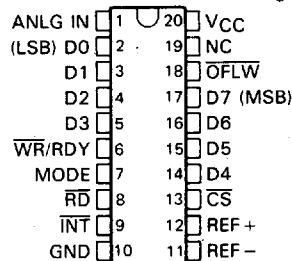
description

The TLC0820A, TLC0820B, ADC0820B, and ADC0820C 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 μ s 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/ μ s without external sampling components. TTL-compatible three-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.

The M-suffix devices are characterized for operation over the full military temperature range of -55°C to 125°C . The I-suffix devices are characterized for operation from -40°C to 85°C . The C-suffix devices are characterized for operation from 0°C to 70°C . See Available Options.

ALL TYPES . . . DW OR N PACKAGE
TLC0820_M . . . J PACKAGE

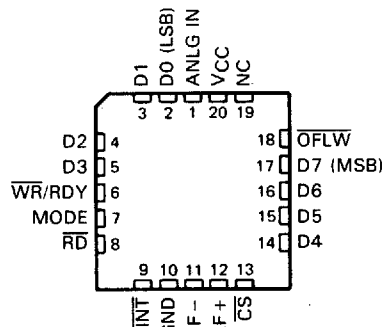
(TOP VIEW)



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TLC0820_M . . . FK PACKAGE
TLC0820_I, TLC0820_C . . . FN PACKAGE
ADC0820_CI, ADC0820_C . . . FN PACKAGE

(TOP VIEW)



NC—No internal connection

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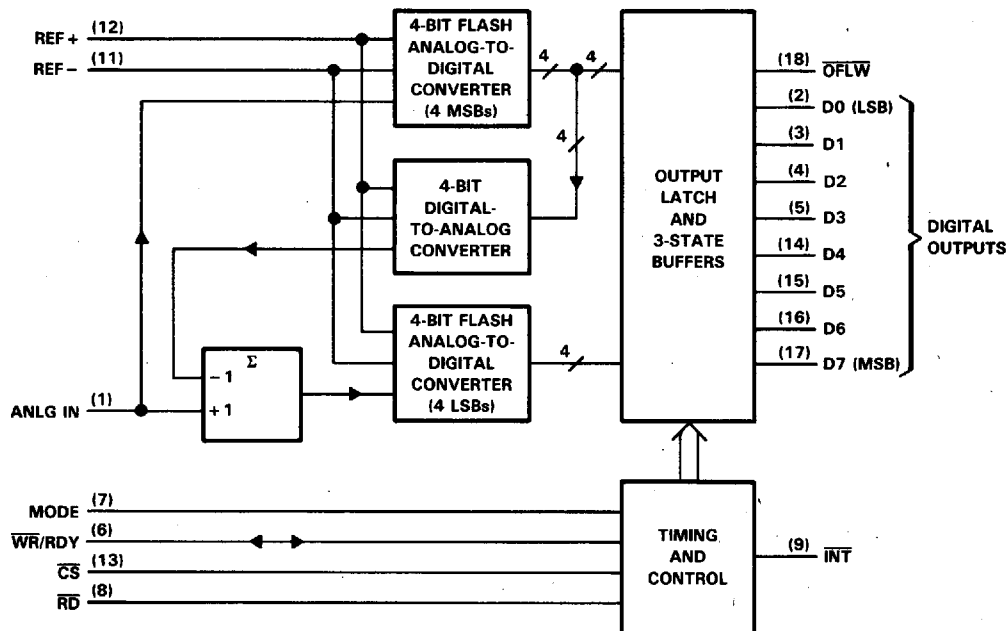
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AVAILABLE OPTIONS

SYMBOLIZATION†		OPERATING TEMPERATURE RANGE	TOTAL UNADJUSTED ERROR
DEVICE	PACKAGE SUFFIX		
TLC0820AC	DW, FN, N	0°C to 70°C	±1 LSB
TLC0820AI	DW, FN, N	-40°C to 85°C	±1 LSB
TLC0820AM	DW, FK, J, N	-55°C to 125°C	±1 LSB
TLC0820BC	DW, FN, N	0°C to 70°C	±0.5 LSB
TLC0820BI	DW, FN, N	-40°C to 85°C	±0.5 LSB
TLC0820BM	DW, FK, J, N	-55°C to 125°C	±0.5 LSB
ADC0820BC	DW, FN, N	0°C to 70°C	±0.5 LSB
ADC0820BCI	DW, FN, N	-40°C to 85°C	±0.5 LSB
ADC0820CC	DW, FN, N	0°C to 70°C	±1 LSB
ADC0820CCI	DW, FN, N	-40°C to 85°C	±1 LSB

†In many instances, these ICs may have both TLC0820 and ADC0820 labeling on the package.

functional block diagram



TLC0820A, TLC0820B, ADC0820B, ADC0820C
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PIN		DESCRIPTION
NAME	NUMBER	
ANLG IN	1	Analog input
\overline{CS}	13	This input must be low in order for \overline{RD} or \overline{WR} to be recognized by the ADC.
D0	2	Three-state data output, bit 1 (LSB)
D1	3	Three-state data output, bit 2
D2	4	Three-state data output, bit 3
D3	5	Three-state data output, bit 4
D4	14	Three-state data output, bit 5
D5	15	Three-state data output, bit 6
D6	16	Three-state data output, bit 7
D7	17	Three-state data output, bit 8 (MSB)
GND	10	Ground
\overline{INT}	9	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. $t_{d(int)}$ is typically 800 ns starting after the rising edge of the \overline{WR} input (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 $t_{d(int)}$ 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	Mode-selection input. It is internally tied to GND through a 50- μ A current source, which acts like a pull-down resistor. READ mode: Occurs when this input is low. WRITE-READ mode: Occurs when this input is high.
NC	19	No internal connection
\overline{OFLW}	18	Normally the \overline{OFLW} output is a logical high. However, if the analog input is higher than the V_{REF+} , \overline{OFLW} will be low at the end of conversion. It can be used to cascade 2 or more devices to improve resolution (9 or 10-bits).
\overline{RD}	8	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 three-state data outputs upon completion of the conversion. The RDY output going into the high-impedance state and \overline{INT} going low indicates completion of the conversion.
REF-	11	This input voltage is placed on the bottom of the resistor ladder.
REF+	12	This input voltage is placed on the top of the resistor ladder.
VCC	20	Power supply voltage
\overline{WR}/RDY	6	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. $t_{d(int)}$ is approximately 800 ns. In the READ mode, RDY (an open-drain output) will go low after the falling edge of \overline{CS} , and will go 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.

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

	TLC0820_M	TLC0820_I ADC0820_CI	TLC0820_C ADC0820_C	UNIT
Supply voltage, V_{CC} (see Note 1)	10	10	10	V
Input voltage range, all inputs (see Note 1)	-0.2 to $V_{CC}+0.2$	-0.2 to $V_{CC}+0.2$	-0.2 to $V_{CC}+0.2$	V
Output voltage range, all outputs (see Note 1)	-0.2 to $V_{CC}+0.2$	-0.2 to $V_{CC}+0.2$	-0.2 to $V_{CC}+0.2$	V
Operating free-air temperature range	-55 to 125	-40 to 85	0 to 70	°C
Storage temperature range	-65 to 150	-65 to 150	-65 to 150	°C
Case temperature for 60 seconds: FK package	260			°C
Case temperature for 10 seconds: FN package		260	260	°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: J package	300			°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: DW or N package	260	260	260	°C

NOTE 1: All voltages are with respect to network ground terminal, pin 10.

recommended operating conditions

	TLC0820_M			TLC0820_I ADC0820_CI			TLC0820_C ADC0820_C			UNIT
	MIN	NOM	MAX	MIN	NOM	MAX	MIN	NOM	MAX	
Supply voltage, V_{CC}	4.5	5	8	4.5	5	8	4.5	5	8	V
Analog input voltage	-0.1	$V_{CC}+0.1$		-0.1	$V_{CC}+0.1$		-0.1	$V_{CC}+0.1$		V
Positive reference voltage, V_{REF+}	V_{REF-}		V_{CC}	V_{REF-}		V_{CC}	V_{REF-}		V_{CC}	V
Negative reference voltage, V_{REF-}	GND		V_{REF+}	GND		V_{REF+}	GND		V_{REF+}	V
High-level input voltage, V_{IH}	$V_{CC} = 4.75$ V to 5.25 V		$\overline{CS}, \overline{WR}/RDY, \overline{RD}$ MODE	2			2			V
Low-level input voltage, V_{IL}	$V_{CC} = 4.75$ V to 5.25 V		$\overline{CS}, \overline{WR}/RDY, \overline{RD}$ MODE	0.8		0.8	0.8		0.8	V
				1.5		1.5	1.5		1.5	
Delay to next conversion, $t_d(NC)$ (see Figures 1, 2, 3, and 4)	500			500			500			ns
Delay time from \overline{WR} to \overline{RD} in write-read mode, t_{dWR} (see Figure 2)	0.4			0.4			0.4			µs
Write-pulse duration in write-read mode, t_{wW} (see Figures 2, 3, and 4)	0.5		50	0.5		50	0.5		50	µs
Operating free-air temperature, T_A	-55		125	-40		85	0		70	°C

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

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

†All typical values are at $T_A = 25^\circ\text{C}$.

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operating characteristics, $V_{CC} = 5\text{ V}$, $V_{REF+} = 5\text{ V}$, $V_{REF-} = 0$, $t_r = t_f = 20\text{ ns}$, $T_A = 25^\circ\text{C}$
(unless otherwise noted)

PARAMETER	TEST CONDITIONS	TLC0820B ADC0820B			TLC0820A ADC0820C			UNIT	
		MIN	TYP	MAX	MIN	TYP	MAX		
k_{SVS}	Supply voltage sensitivity	$V_{CC} = 5\text{ V} \pm 5\%$, $T_A = \text{MIN to MAX}$			$\pm 1/16$	$\pm 1/4$	$\pm 1/16$	$\pm 1/4$	LSB
	Total unadjusted error†	MODE pin at 0 V, $T_A = \text{MIN to MAX}$			1/2		1	LSB	
t_{convR}	Read mode conversion time	MODE pin at 0 V, See Figure 1			1.6	2.5	1.6	2.5	μs
$t_{d(int)}$	Internal count-down delay time	MODE pin at 5 V, $C_L = 50\text{ pF}$, See Figures 3 and 4			800	1300	800	1300	ns
t_{aR}	Access time from $\overline{RD}\downarrow$	MODE pin at 0 V, See Figure 1			$t_{convR} + 20$	$t_{convR} + 50$	$t_{convR} + 20$	$t_{convR} + 50$	ns
t_{aR1}	Access time from $\overline{RD}\downarrow$	MODE pin at 5 V, $t_{dWR} < t_{d(int)}$, See Figure 2	$C_L = 15\text{ pF}$	190	280	190	280	ns	
			$C_L = 100\text{ pF}$	210	320	210	320		
t_{aR2}	Access time from $\overline{RD}\downarrow$	MODE pin at 5 V, $t_{dWR} > t_{d(int)}$, See Figure 3	$C_L = 15\text{ pF}$	70	120	70	120	ns	
			$C_L = 100\text{ pF}$	90	150	90	150		
t_{aINT}	Access time from $\overline{INT}\downarrow$	MODE pin at 5 V, See Figure 4			20	50	20	50	ns
t_{dis}	Disable time from $\overline{RD}\uparrow$	$R_L = 1\text{ k}\Omega$, $C_L = 10\text{ pF}$, See Figures 1, 2, 3, and 5			70	95	70	95	ns
t_{dRDY}	Delay time from $\overline{CS}\downarrow$ to $\overline{RDY}\downarrow$	MODE pin at 0 V, $C_L = 50\text{ pF}$, See Figure 1			50	100	50	100	ns
t_{dRIH}	Delay time from $\overline{RD}\uparrow$ to $\overline{INT}\uparrow$	$C_L = 50\text{ pF}$, See Figures 1, 2, and 3			125	225	125	225	ns
t_{dRIL}	Delay time from $\overline{RD}\downarrow$ to $\overline{INT}\downarrow$	MODE pin at 5 V, $t_{dWR} < t_{d(int)}$, See Figure 2			200	290	200	290	ns
t_{dWIH}	Delay time from $\overline{WR}\uparrow$ to $\overline{INT}\uparrow$	MODE pin at 5 V, $C_L = 50\text{ pF}$, See Figure 4			175	270	175	270	ns
	Slew rate tracking				0.1		0.1		$\text{V}/\mu\text{s}$

† Total unadjusted error includes offset, full-scale, and linearity errors.

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PARAMETER MEASUREMENT INFORMATION

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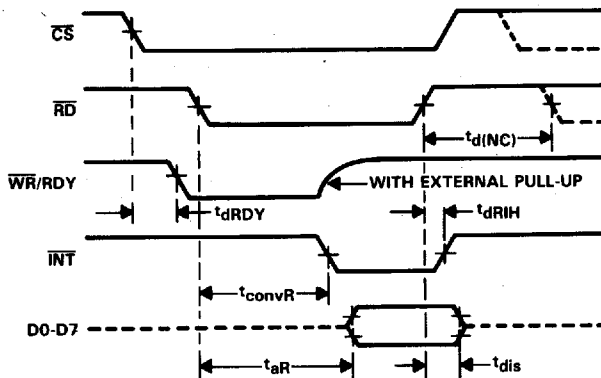


FIGURE 1. READ MODE WAVEFORMS (MODE PIN LOW)

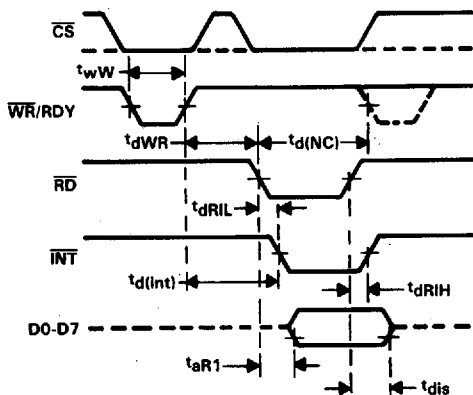


FIGURE 2. WRITE-READ MODE WAVEFORMS
 [MODE PIN HIGH AND $t_{dWR} < t_{d(int)}$]

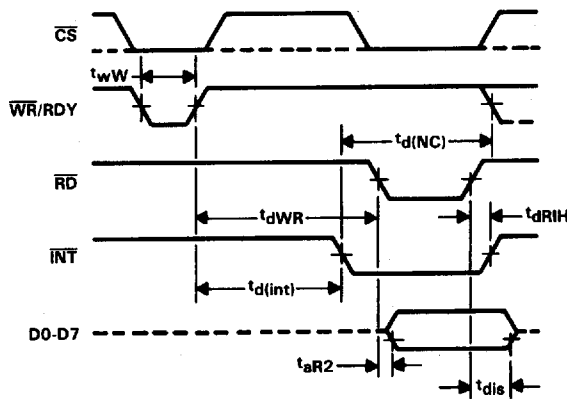


FIGURE 3. WRITE-READ WAVEFORMS
 [MODE PIN HIGH AND $t_{dWR} > t_{d(int)}$]

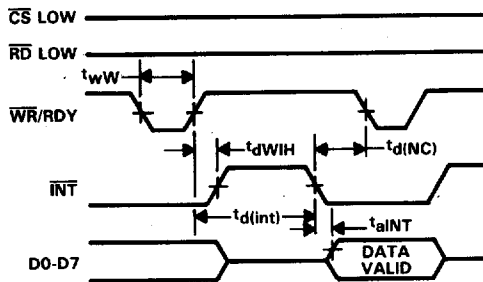
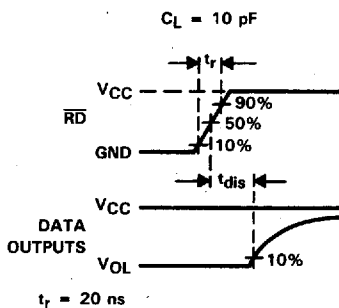
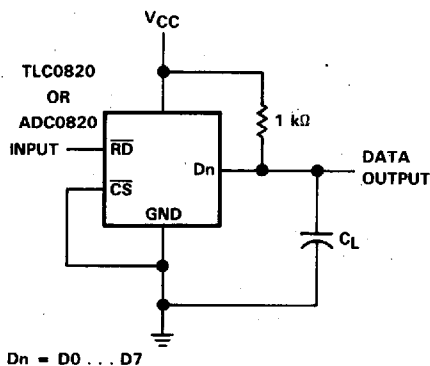
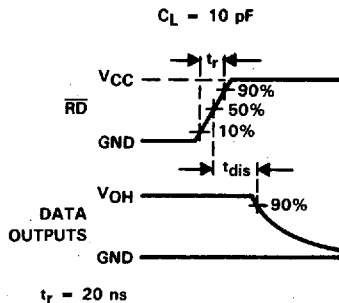
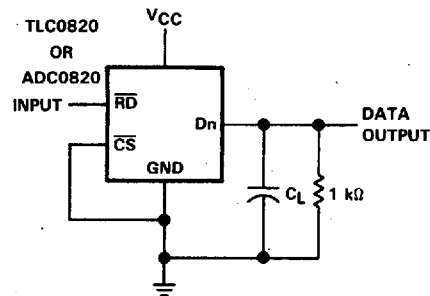


FIGURE 4. WRITE-READ MODE WAVEFORMS
 (STAND-ALONE OPERATION, MODE PIN HIGH, AND RD LOW)

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PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

FIGURE 5. TEST CIRCUIT AND VOLTAGE WAVEFORMS

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PRINCIPLES OF OPERATION

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The TLC0820A, TLC0820B, ADC0820B and ADC0820C 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 $V_{CC} + 0.1\text{ V}$. Analog input signals that are less than $V_{REF-} + \frac{1}{2}\text{ LSB}$ or greater than $V_{REF+} - \frac{1}{2}\text{ LSB}$ 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, which are selected by the MODE pin (pin 7). The converter is set to the read (only) mode when pin 7 is low. In the read mode, the $\overline{\text{WR/RDY}}$ pin is used as an output and is referred to as the "ready" pin. In this mode, a low on the "ready" pin while $\overline{\text{CS}}$ is low indicates that the device is busy. Conversion starts on the falling edge of $\overline{\text{RD}}$ and is completed no more than $2.5\ \mu\text{s}$ later when $\overline{\text{INT}}$ falls and the "ready" pin returns to a high-impedance state. Data outputs also change from high-impedance to active states at this time. After the data is read, $\overline{\text{RD}}$ is taken high, $\overline{\text{INT}}$ returns high, and the data outputs return to their high-impedance states.

The converter is set to the write-read mode when pin 7 is high and $\overline{\text{WR/RDY}}$ is referred to as the "write" pin. Taking $\overline{\text{CS}}$ and the "write" pin low selects the converter and initiates measurement of the input signal. Approximately 600 ns after the "write" pin returns high, the conversion is completed. Conversion starts on the rising edge of $\overline{\text{WR/RDY}}$ 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 three-state buffers on the falling edge of $\overline{\text{RD}}$.

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TYPICAL APPLICATION DATA

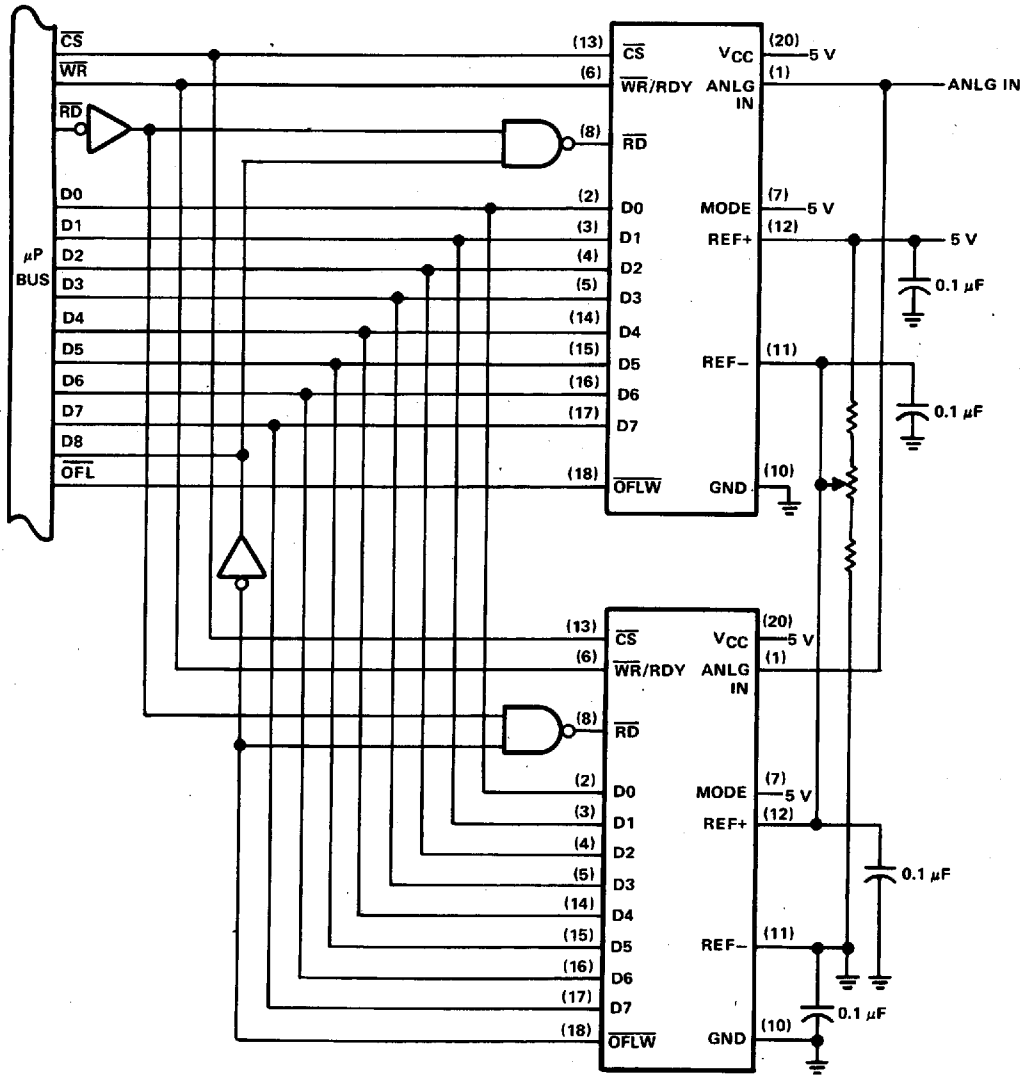


FIGURE 6. CONFIGURATION FOR 9-BIT RESOLUTION