

# 8-Bit, high-speed, $\mu$ P-compatible A/D converter with track/hold function

## ADC0820

### DESCRIPTION

By using a half-flash conversion technique, the 8-bit ADC0820 CMOS A/D offers a 1.5 $\mu$ s conversion time while dissipating a maximum 75mW of power. The half-flash technique consists of 31 comparators, a most significant 4-bit ADC and a least significant 4-bit ADC.

The input to the ADC0820 is tracked and held by the input sampling circuitry, eliminating the need for an external sample-and-hold for signals slewing at less than 100mV/ $\mu$ s.

For ease of interface to microprocessors, the ADC0820 has been designed to appear as a memory location or I/O port without the need for external interfacing logic.

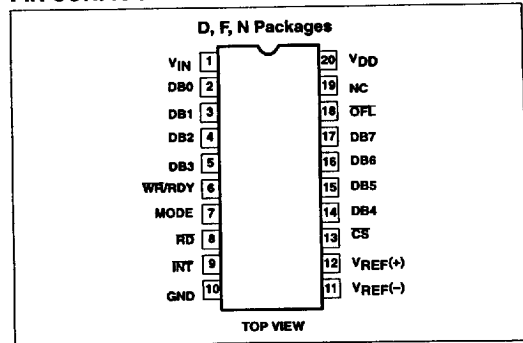
### FEATURES

- Built-in track-and-hold function
- No missing codes
- No external clocking
- Single supply—5V<sub>DC</sub>
- Easy interface to all microprocessors, or operates stand-alone
- Latched 3-State outputs
- Logic inputs and outputs meet both MOS and TTL voltage level specifications
- Operates ratiometrically or with any reference value equal to or less than V<sub>DD</sub>
- 0V to 5V analog input voltage range with single 5V supply
- No zero- or full-scale adjust required
- Overflow output available for cascading
- 0.3" standard width 20-pin DIP

### ORDERING INFORMATION

DESCRIPTION	TEMPERATURE RANGE	ORDER CODE	DWG #
20-Pin Plastic Dual In-Line Package (DIP)	0 to +70°C	ADC0820CNEN	0408B
20-Pin Plastic Small Outline (SO) package	0 to +70°C	ADC0820CNED	1021B

### PIN CONFIGURATION



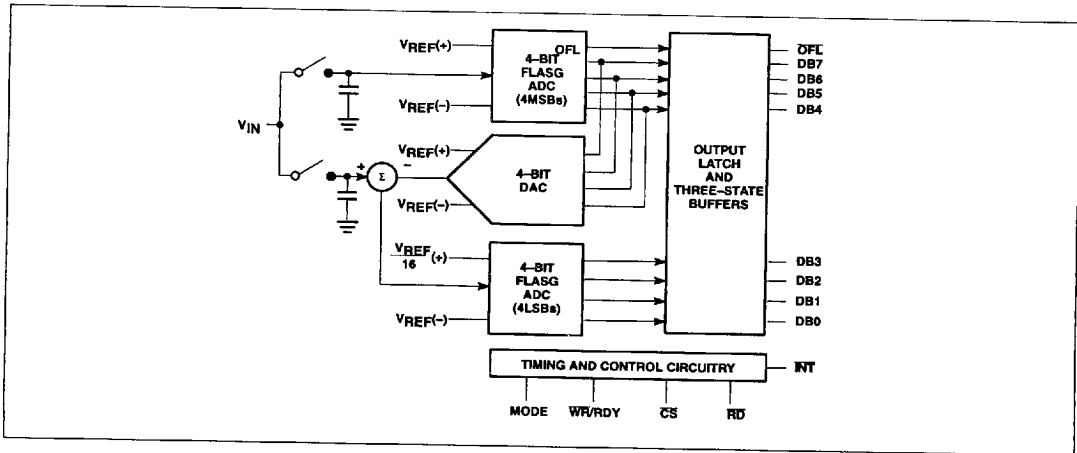
### APPLICATIONS

- Microprocessor-based monitoring and control systems
- Transducer/ $\mu$ P interface
- Process control
- Logic analyzers
- Test and measurement

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## BLOCK DIAGRAM



## PIN DESCRIPTION

PIN NO	SYMBOL	DESCRIPTION
1	$V_{IN}$	Analog input; range= $GND \leq V_{IN} \leq V_{DD}$
2	DB0	3-state data output—Bit 0 (LSB)
3	DB1	3-state data output—Bit 1
4	DB2	3-state data output—Bit 2
5	DB3	3-state data output—Bit 3
6	WR/RDY	<p><b>WR-RD Mode</b></p> <p>WR: With <math>\overline{CS}</math> Low, the conversion is started on the falling edge of WR. Approximately 800ns (the preset internal time out, <math>t_1</math>) after the WR rising edge, the result of the conversion will be strobed into the output latch, provided that <math>\overline{RD}</math> does not occur prior to this time out (see Figures 3a and 3b).</p> <p><b>RD Mode</b></p> <p>RDY: This is an open-drain output (no internal pull-up device). RDY will go Low after the falling edge of <math>\overline{CS}</math>; RDY will go 3-State when the result of the conversion is strobed into the output latch. It is used to simplify the interface to a microprocessor system (see Figure 1).</p>
7	Mode	<p>Mode: Mode selection input—it is internally tied to GND through a 30<math>\mu</math>A current source.</p> <p>RD Mode: When mode is Low.</p> <p>WR-RD Mode: When mode is High.</p>
8	$\overline{RD}$	<p><b>WR-RD Mode</b></p> <p>With <math>\overline{CS}</math> Low, the 3-State data outputs (DB0-DB7) will be activated when <math>\overline{RD}</math> goes Low. <math>\overline{RD}</math> can also be used to increase the speed of the converter by reading data prior to the preset internal time out (<math>T_1 \sim 800</math>ns). If this is done, the data result transferred to output latch is latched after the falling edge of the <math>\overline{RD}</math> (see Figures 3a and 3b).</p> <p><b>RD Mode</b></p> <p>With <math>\overline{CS}</math> Low, the conversion will start with <math>\overline{RD}</math> going Low; also, <math>\overline{RD}</math> will enable the 3-State data outputs at the completion of the conversion. RDY going 3-State and INT going Low indicate the completion of the conversion (see Figure 1).</p>
9	INT	<p><b>WR-RD Mode</b></p> <p>INT going Low indicates that the conversion is completed and the data result is in the output latch. INT will go Low <math>\sim 800</math>ns (the preset internal time out, <math>t_1</math>) after the rising edge of WR (see Figure 3a); or INT will go Low after the falling edge of <math>\overline{RD}</math>, if <math>\overline{RD}</math> goes Low prior to the 800ns time out (see Figure 3b). INT is reset by the rising edge of <math>\overline{RD}</math> or <math>\overline{CS}</math> (see Figures 3a and 3b).</p>

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PIN DESCRIPTION (Continued)

PIN NO	SYMBOL	DESCRIPTION
		<b>RD Mode</b>
		$\overline{\text{INT}}$ going Low indicates that the conversion is completed and the data result is in the output latch. $\overline{\text{INT}}$ is reset by the rising edge of RD or CS (see Figure 1).
10	GND	Ground
11	V <sub>REF(-)</sub>	The bottom of resistor ladder, voltage range: $\text{GND} \leq \text{V}_{\text{REF}(-)} \leq \text{V}_{\text{REF}(+)}$
12	V <sub>REF(+)</sub>	The top of resistor ladder, voltage range: $\text{V}_{\text{REF}(-)} \leq \text{V}_{\text{REF}(+)} \leq \text{V}_{\text{DD}}$ .
13	$\overline{\text{CS}}$	$\overline{\text{CS}}$ must be Low in order for the RD or WR to be recognized by the converter.
14	DB4	3-State data output—Bit 4
15	DB5	3-State data output—Bit 5
16	DB6	3-State data output—Bit 6
17	DB7	3-State data output—Bit 7 (MSB)
18	OFL	Overflow output—if the analog input is higher than the V <sub>REF(+)</sub> -LSB, OFL will be low at the end of conversion. It can be used to cascade 2 or more devices to have more resolution (9, 10-bit). It is always active and never becomes 3-state.
19	NC	No connection
20	V <sub>DD</sub>	Power supply voltage

ABSOLUTE MAXIMUM RATINGS<sup>1, 2</sup>

SYMBOL	PARAMETER	RATING	UNIT
V <sub>DD</sub>	Supply voltage	7	V
	Logic control inputs	-0.2 to V <sub>DD</sub> +0.2	V
	Voltage at other inputs and output	-0.2 to V <sub>DD</sub> +0.2	V
T <sub>STG</sub>	Storage temperature range	-65 to +150	°C
P <sub>D</sub>	Maximum power dissipation <sup>3</sup> T <sub>A</sub> =25°C(still-air)		
	N package	1690	mW
	D package	1390	mW
T <sub>SOLD</sub>	Lead temperature (soldering, 10sec)	300	°C
T <sub>A</sub>	Operating ambient temperature range ADC0820CNEN/CNED	T <sub>MIN</sub> ≤ T <sub>A</sub> ≤ T <sub>MAX</sub> 0 to +70	°C

NOTES:

- Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.
- All voltages are measured with respect to GND, unless otherwise specified.
- Derate above 25°C at the following rates:  
N package at 13.5mW/°C  
D package at 11.1mW/°C

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## DC ELECTRICAL CHARACTERISTICS

RD mode (Pin 7=0),  $V_{\text{DD}}=5\text{V}$ ,  $V_{\text{REF}(+)}=5\text{V}$ , and  $V_{\text{REF}(-)}=\text{GND}$ , unless otherwise specified. Limits apply from  $T_{\text{MIN}}$  to  $T_{\text{MAX}}$ .

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS			UNIT
			Min	Typ <sup>3</sup>	Max	
	Resolution		8	8	8	bits
	Unadjusted error <sup>1</sup>	ADC0820C			$\pm 1$	LSB
$R_{\text{REF}}$	Reference resistance		1	1.6	4	$\text{k}\Omega$
$V_{\text{REF}(+)}$	Input voltage <sup>5</sup>		$V_{\text{REF}(-)}$		$V_{\text{DD}}$	V
$V_{\text{REF}(-)}$	Input voltage		GND		$V_{\text{REF}(+)}$	V
$V_{\text{IN}}$	Input voltage <sup>5</sup>		GND-0.1		$V_{\text{DD}}+0.1$	V
	Maximum analog input leakage current	$\text{CS}=V_{\text{DD}}$ $V_{\text{IN}}=V_{\text{DD}}$ $V_{\text{IN}}=\text{GND}$	-3		3	$\mu\text{A}$
	Power supply sensitivity	$V_{\text{DD}}=5\text{V}\pm 5\%$		$\pm 1/16$	$\pm 1/4$	LSB
$V_{\text{IN}(1)}$	Logical "1" input voltage	$V_{\text{DD}}=5.25\text{V}$	$\text{CS}, \text{WR}, \text{RD}$ Mode	2.0 3.5	$V_{\text{DD}}$ $V_{\text{DD}}$	V
$V_{\text{IN}(0)}$	Logical "0" input voltage	$V_{\text{DD}}=4.75\text{V}$	$\text{CS}, \text{WR}, \text{RD}$ Mode	GND GND	0.8 1.5	V
$I_{\text{IN}(1)}$	Logical "1" input current	$V_{\text{IN}(1)}=5\text{V}; \text{CS}, \text{RD}$ $V_{\text{IN}(1)}=5\text{V}; \text{WR}$ $V_{\text{IN}(1)}=5\text{V}; \text{Mode}$			1 3 30	$\mu\text{A}$
$I_{\text{IN}(0)}$	Logical "0" input current	$V_{\text{IN}(0)}=0\text{V}; \text{CS}, \text{RD}, \text{WR}, \text{Mode}$	-1			$\mu\text{A}$
$V_{\text{OUT}(1)}$	Logical "1" output voltage	$V_{\text{DD}}=4.75\text{V}, I_{\text{OUT}}=-360\mu\text{A};$ DB0-DB7, OFL, INT	2.4	4.6		V
		$V_{\text{DD}}=4.75\text{V}, I_{\text{OUT}}=-10\mu\text{A}$ DB0-DB7, OFL, INT	4.5	4.74		
$V_{\text{OUT}(0)}$	Logical "0" output voltage	$V_{\text{DD}}=4.75\text{V}, I_{\text{OUT}}=1.6\text{mA};$ DB0-DB7, OFL, INT, RDY		0.2	0.4	V
$I_{\text{OZ}}$	3-state output current	$V_{\text{OUT}}=5\text{V}; \text{DB0-DB7}, \text{RDY}$ $V_{\text{OUT}}=0\text{V}; \text{DB0-DB7}, \text{RDY}$			3	$\mu\text{A}$
		$V_{\text{OUT}}=0\text{V}, \text{DB0-DB7}, \text{OFL}$	-3			
$I_{\text{SOURCE}}$	Output source current	$V_{\text{OUT}}=0\text{V}, \text{DB0-DB7}, \text{OFL}$ INT	6	12		mA
$I_{\text{SINK}}$	Output sink current	$V_{\text{OUT}}=5\text{V}; \text{DB0-DB7}, \text{OFL}, \text{INT}, \text{RDY}$	4.5	8		mA
$I_{\text{DD}}$	Supply current	$\text{CS}=\text{WR}=\text{RD}=0$		6	15	mA
$V_{\text{DD}}$	Range		4.5		5.5	V

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## AC ELECTRICAL CHARACTERISTICS

 $V_{\text{DD}} = 5\text{V}$ ,  $t_{\text{R}} = t_{\text{F}} = 20\text{ns}$ ,  $V_{\text{REF}(+)} = 5\text{V}$ ,  $V_{\text{REF}(-)} = 0\text{V}$ , and  $T_{\text{A}} = 25^{\circ}\text{C}$ , unless otherwise specified.

SYMBOL	PARAMETER		TEST CONDITIONS	LIMITS <sup>4</sup>			UNIT
				Min	Typ <sup>3</sup>	Max	
$t_{\text{CRD}}$	Conversion time for RD mode		Mode=0, Figure 1		1.6	2.5	$\mu\text{s}$
$t_{\text{ACCO}}$	Access time (delay from falling edge of RD to output valid)		Mode=0, Figure 1		$t_{\text{CRD}}+20$	$t_{\text{CRD}}+50$	ns
$t_{\text{CWR-RD}}$	Conversion time for WR-RD mode		Mode= $V_{\text{DD}}$ , $t_{\text{WR}}=600\text{ns}$ , $t_{\text{RD}}=600\text{ns}$ ; Figures 3a and 3b			1.52	$\mu\text{s}$
$t_{\text{WR}}$	Write time	Min	Mode= $V_{\text{DD}}$ , Figures 3a and 3b <sup>2</sup>	600			ns
		Max				50	$\mu\text{s}$
$t_{\text{RD}}$	Read time	Min	Mode= $V_{\text{DD}}$ , Figures 3a and 3b <sup>2</sup>	600			ns
$t_{\text{ACC1}}$	Access time (delay from falling edge of RD to output valid)		Mode= $V_{\text{DD}}$ , $t_{\text{RD}}<t_{\text{i}}$ ; Figure 3b, $C_{\text{L}}=15\text{pF}$		190	280	ns
			$C_{\text{L}}=100\text{pF}$		210	320	
$t_{\text{ACC2}}$	Access time (delay from falling edge of RD to output valid)		Mode= $V_{\text{DD}}$ , $t_{\text{RD}}>t_{\text{i}}$ ; Figure 3a, $C_{\text{L}}=15\text{pF}$		70	120	ns
			$C_{\text{L}}=100\text{pF}$		90	150	ns
$t_{\text{i}}$	Internal comparison time		Mode= $V_{\text{DD}}$ ; Figures 2 and 3a, $C_{\text{L}}=50\text{pF}$		800	1300	ns
$t_{\text{1H}}$ , $t_{\text{0H}}$	Three-state control (delay from rising edge of RD to Hi-Z state)		$R_{\text{L}}=1\text{k}\Omega$ , $C_{\text{L}}=10\text{pF}$		100	200	ns
$t_{\text{INTL}}$	Delay from rising edge of WR to falling edge of INT		Mode= $V_{\text{DD}}$ , $C_{\text{L}}=50\text{pF}$ $t_{\text{RD}}>t_{\text{i}}$ ; Figure 3a $t_{\text{RD}}<t_{\text{i}}$ ; Figure 3b		$t_{\text{RD}}+200$	$t_{\text{i}}$ $t_{\text{RD}}+290$	ns ns
$t_{\text{INTH}}$	Delay from rising edge of RD to rising edge of INT		Figures 1, 3a, and 3b, $C_{\text{L}}=50\text{pF}$		125	225	ns
$t_{\text{INTHWR}}$	Delay from rising edge of WR to rising edge of INT		Figure 2, $C_{\text{L}}=50\text{pF}$		175	270	ns
$t_{\text{RDY}}$	Delay from CS to RDY		Figure 1, $C_{\text{L}}=50\text{pF}$ , Mode=0		50	100	ns
$t_{\text{D}}$	Delay from INT to output valid		Figure 2		20	50	ns
$t_{\text{RI}}$	Delay from RD to INT		Mode= $V_{\text{DD}}$ , $t_{\text{RD}}<t_{\text{i}}$ ; Figure 3b		200	290	ns
$t_{\text{P}}$	Delay from end of conversion to next conversion		Figures 1, 2, 3a, and 3b <sup>2</sup>	500			ns
SR	Slew rate, tracking				0.1		V/ $\mu\text{s}$
$C_{\text{VIN}}$	Analog input capacitance				45		pF
$C_{\text{OUT}}$	Logic output capacitance				5		pF
$C_{\text{IN}}$	Logic input capacitance				5		pF

## NOTES:

- Unadjusted error includes offset, full-scale, and linearity errors.
  - Accuracy may degrade if  $t_{\text{WR}}$  or  $t_{\text{RD}}$  is shorter than the minimum value specified.
  - Typical values are at  $25^{\circ}\text{C}$  and represent most likely parametric norm.
  - Guaranteed but not 100% production tested. These limits are not used to calculate outgoing quality levels.
5.  $V_{\text{REF}}$  and  $V_{\text{IN}}$  must be applied after  $V_{\text{CC}}$  has been turned on to prevent possibility of latching.

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## 3-STATE TEST CIRCUITS AND WAVEFORMS

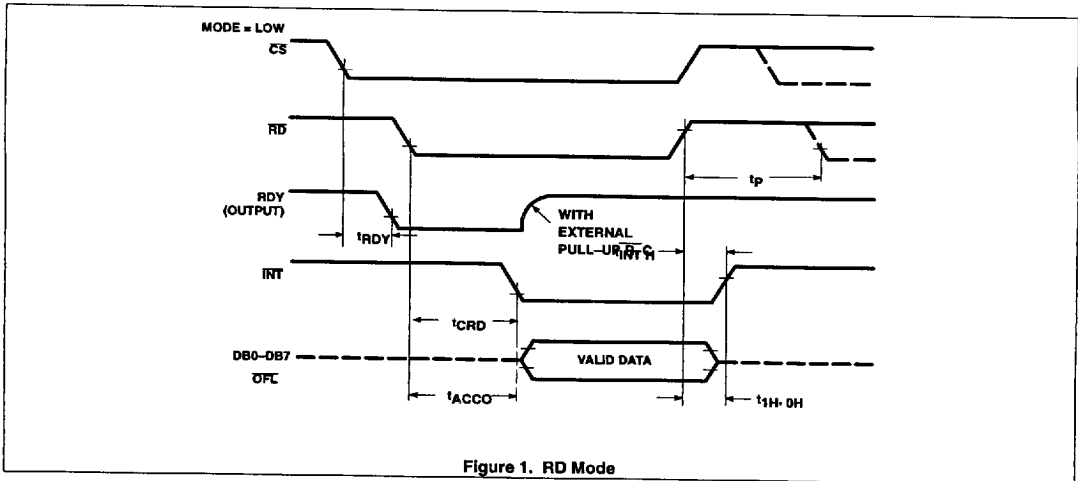
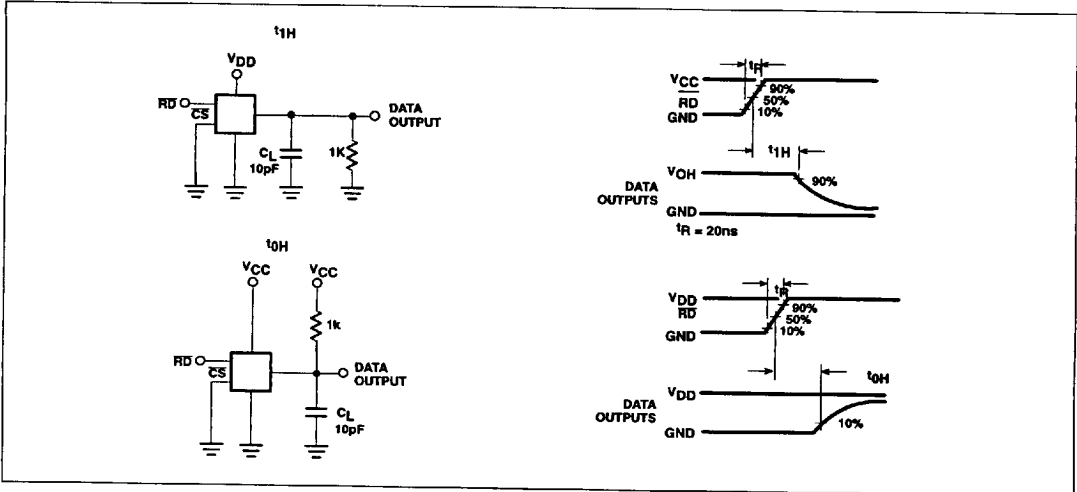
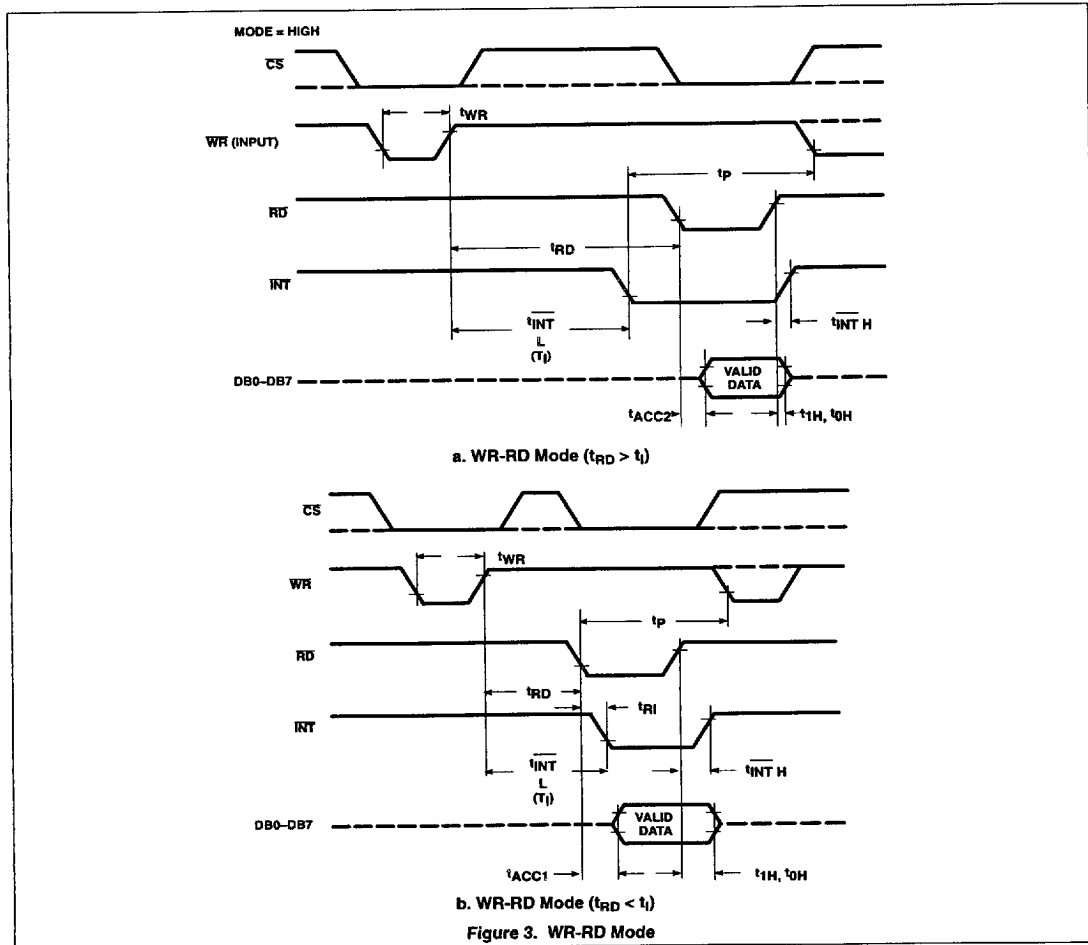
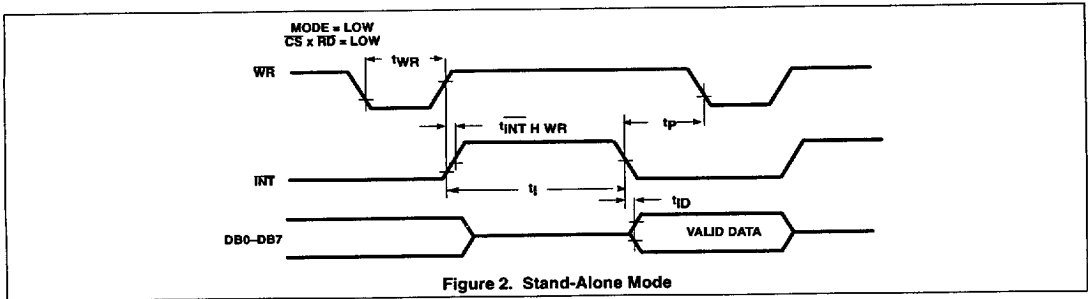


Figure 1. RD Mode

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## FUNCTIONAL DESCRIPTION

### General Operation

The ADC0820 uses two 4-bit flash A/D converters to make an 8-bit measurement (Block Diagram). Each flash ADC is made up of 15 comparators which compare the unknown input to a reference ladder to get a 4-bit result. To take a full 8-bit reading, one flash conversion is done to provide the 4 most significant data bits (via the MS flash ADC). Driven by the 4 MSBs, an internal DAC recreates an analog approximation of the input voltage. This analog signal is then subtracted from the input, and the difference voltage is converted by a second 4-bit flash ADC (the LS ADC), providing the 4 least significant bits of the output data word.

The internal DAC is actually a subsection of the MS flash converter. This is accomplished by using the same resistor ladder for the A/D as well as for generating the DAC signal. The DAC output is actually the tap on the resistor ladder which most closely approximates the analog input. In addition, the "sampled data" comparators used in the ADC0820 provide the ability to compare the magnitudes of several analog signals simultaneously, without using input summing amplifiers. This is especially useful in the LS flash ADC, where the signal to be converted is an analog difference.

### The Sampled-Data Comparator

Each comparator in the ADC0820 consists of a CMOS inverter with a capacitively-coupled input (Figure 4). Analog switches connect the two comparator inputs to the input capacitor (C) and also connect the inverter's input and output. This device in effect now has one differential input pair. A comparison requires two cycles, one for zeroing the comparator, and another for making the comparison.

In the first cycle, one input switch and the inverter's feedback switch (Figure 4a) are closed. In this interval, C is charged to the connected input (V1) less the inverter's bias voltage (V<sub>S</sub>, approximately 1.6V). In the second cycle (Figure 4b), these two switches are opened and the other (V2) input's switch is closed. The input capacitor now subtracts its stored voltage from the second input and the difference is amplified by the inverter's open loop gain. The inverter's input (V'<sub>S</sub>) becomes

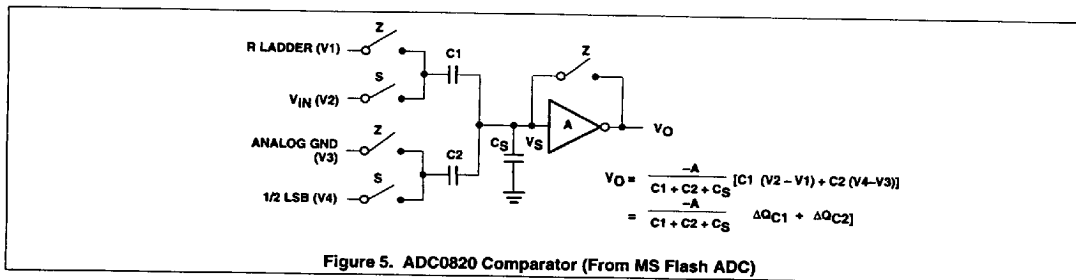
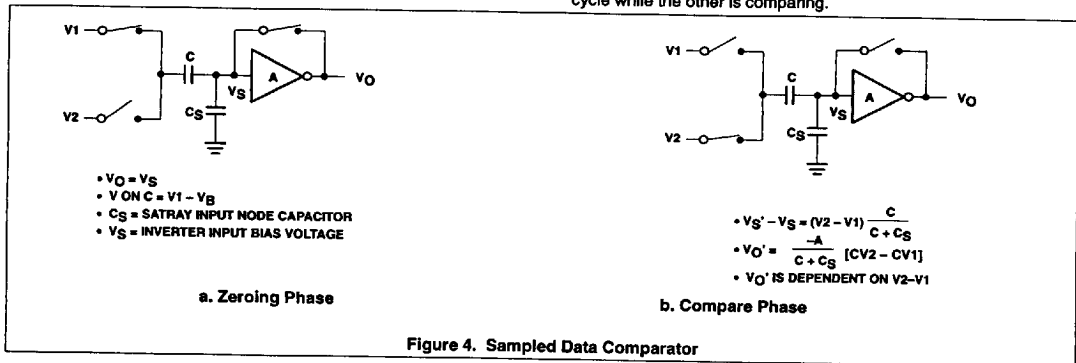
$$V'_S = V_S + (V_2 - V_1) \frac{C}{C + C_S}$$

and the output will go High or Low depending on the sign of V'<sub>S</sub>-V<sub>S</sub>.

The actual circuitry used in the ADC0820 is a simple but important expansion of the basic comparator described above. By adding a second capacitor and another set of switches to the input (Figure 5), the scheme can be expanded to make dual differential comparisons. In this circuit, the feedback switch and one input switch on each capacitor (Z switches) are closed in the zeroing cycle. A comparison is then made by connecting the second input on each capacitor (S switches) and opening all of the other switches. The change in voltage at the inverter's input, as a result of the change in charge on each input capacitor, will now depend on both input signal differences.

### Architecture

In the ADC0820, 15 comparators are used in the MS and LS 4-bit flash A/D converters. The MS (most significant) flash ADC also has one additional comparator to detect input over-range. These two sets of comparators operate alternately, with one group in its zeroing cycle while the other is comparing.





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To start a conversion in the WR-RD mode, the WR line is brought Low. At this instant the MS comparators go from zeroing to compare mode (Figure 8). When WR is returned High after at least 600ns, the output from the first set of comparators (the first flash) is decoded and latched. At this point the two 4-bit converters change modes and the LS (least significant) flash ADC enters its compare cycle. No less than 600ns later, the RD line may be pulled Low to latch the lower four data bits and finish the 8-bit conversion. When RD goes Low, the flash A/Ds change state once again in preparation for the next conversion.

Figure 8 also outlines how the converter's interface timing relates to its analog input ( $V_{IN}$ ). In WR-RD mode,  $V_{IN}$  is measured while WR is Low. In RD mode, sampling occurs during the first 800ns of RD. Because of the input connections to the ADC0820's LS and MS comparators, the converter has the ability to sample  $V_{IN}$  at one instant, despite the fact that two separate 4-bit conversions are being done. More specifically, when WR is Low the MS flash is in compare mode (connected to  $V_{IN}$ , and the LS flash is in zero mode (also connected to  $V_{IN}$ ). Therefore both flash ADCs sample  $V_{IN}$  at the same time.

### Digital Interface

The ADC0820 has two basic interface modes which are selected by strapping the Mode pin High or Low.

#### RD Mode (Figure 6a)

With the Mode pin grounded, the converter is set to Read mode. In this configuration, a complete conversion is done by pulling RD Low until output data appears. An INT line is provided which goes Low at the end of the conversion as well as a RDY output which can be used to signal a processor that the converter is busy or can also serve as a system Transfer Acknowledge signal.

When in RD mode, the comparator phases are internally triggered. At the falling edge of RD, the MS flash converter goes from zero to compare mode and the LS ADC's comparators enter their zero cycle. After 800ns, data from the MS flash is latched and the LS flash ADC enters compare mode. Following another 800ns, the lower four bits are recovered.

#### WR Then RD Mode (Figures 6b and c)

With the Mode pin tied High, the A/D will be set up for the WR-RD mode. Here, a conversion is started with the WR input; however, there are two options for reading the output data which relate to interface timing. If an interrupt-driven scheme is desired, the user can wait for INT to go Low

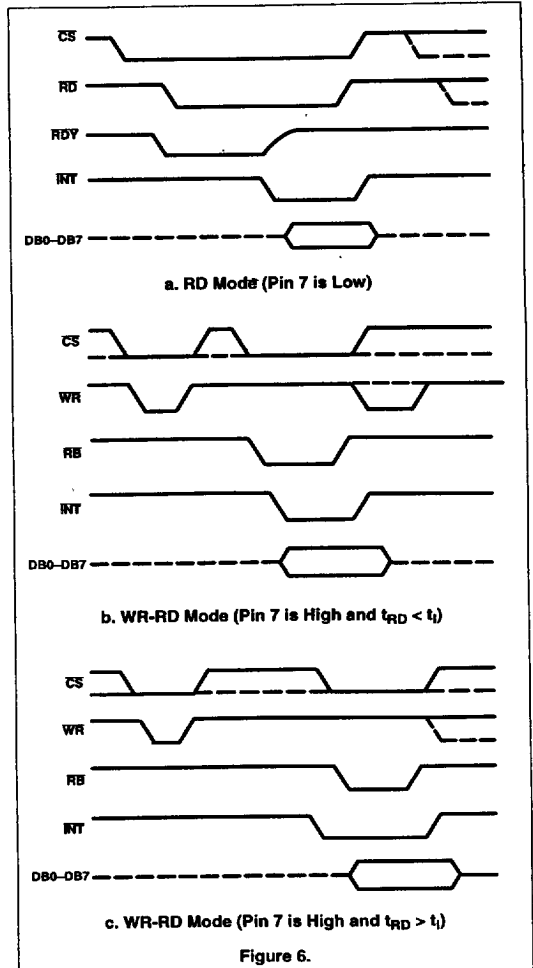


Figure 6.



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before reading the conversion result.  $\overline{INT}$  will typically go Low 800ns after  $\overline{WR}$ 's rising edge. However, if a shorter conversion time is desired, the processor need not wait for  $\overline{INT}$  and can exercise a Read after only 600ns. If this is done,  $\overline{INT}$  will immediately go Low and data will appear at the outputs.

## Stand-Alone (Figure 7)

For stand-alone operation in  $\overline{WR}$ -RD mode,  $\overline{CS}$  and  $\overline{RD}$  can be tied Low and a conversion can be started with  $\overline{WR}$ . Data will be valid approximately 800ns following  $\overline{WR}$ 's rising edge.

## Other Interface Considerations

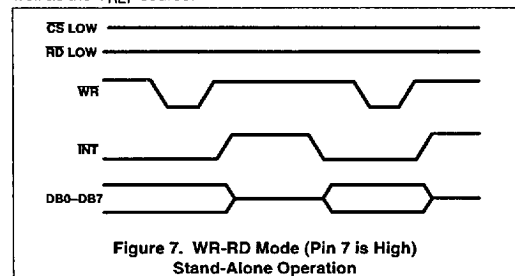
In order to maintain conversion accuracy,  $\overline{WR}$  has a maximum width spec of 50 $\mu$ s. When the MS flash ADC's sampled data comparators are in comparison mode ( $\overline{WR}$  is Low), the input capacitors (C, Figure 5) must hold their charge. Switch leakage can cause errors if the comparator is left in this phase for too long.

Since the MS flash ADC enters its zeroing phase at the end of a conversion, a new conversion cannot be started until this phase is complete. The minimum spec for this time is 500ns ( $t_p$  in Figures 1, 2, 3a, and 3b).

## ANALOG CONSIDERATIONS

### Reference and Input

The two  $V_{REF}$  inputs of the ADC0820 are fully differential and define the zero- to full-scale input range of the A/D converter. This allows the designer to easily vary the span of the analog input since this range will be equivalent to the voltage difference between  $V_{IN}(+)$  and  $V_{IN}(-)$ . By reducing  $V_{REF}(V_{REF}=V_{REF}(+) - V_{REF}(-))$  to less than 5V, the sensitivity of the converter can be increased (i.e., if  $V_{REF}=2V$ , then 1 LSB=7.8mV). The input/reference arrangement also facilitates ratiometric operation and, in many cases, the chip power supply can be used for transducer power as well as the  $V_{REF}$  source.



This reference flexibility lets the input span not only be varied, but also offset from zero. The voltage at  $V_{REF}(-)$  sets the input level which produces a digital output of all zeroes. Though  $V_{IN}$  is not itself differential, the reference design affords nearly differential-input capability for most measurement applications. Figure 9 shows some of the configurations that are possible.

### Input Current

Due to the unique conversion techniques employed by the ADC0820, the analog input behaves somewhat differently than in conventional devices. The A/D's sampled data comparators take varying amounts of input current depending on which cycle the conversion is in.

The equivalent input circuit of the ADC0820 is shown in Figure 10a. When a conversion starts ( $\overline{WR}$  Low,  $\overline{WR}$ -RD mode), all input switches close, connecting  $V_{IN}$  to 31 1pF capacitors. Although the two 4-bit flash circuits are not both in their compare cycle at the same time,  $V_{IN}$  still sees all input capacitors at once. This is because the MS flash converter is connected to the input during its compare interval and the LS flash is connected to the input during its zeroing phase. In other words, the LS ADC uses  $V_{IN}$  as its zero-phase input.

The input capacitors must charge to the input voltage through the on resistance of the analog switches (about 5k $\Omega$  to 10k $\Omega$ ). In addition, about 12pF of input stray capacitance must also be charged. For large source resistances, the analog input can be modeled as an RC network as shown in Figure 10b. As  $R_S$  increases, it will take longer for the input capacitance to charge.

In RD mode, the input switches are closed for approximately 800ns at the start of the conversion. In  $\overline{WR}$ -RD mode, the time that the switches are closed to allow this charging is the time that  $\overline{WR}$  is Low. Since other factors force this time to be at least 600ns, input time constants of 100ns can be accommodated without special consideration. Typical total input capacitance values of 45pF allow  $R_S$  to be 1.5k $\Omega$  without lengthening  $\overline{WR}$  to give  $V_{IN}$  more time to settle.

### Input Filtering

It should be made clear that transients in the analog input signal, caused by charging current flowing into  $V_{IN}$ , will not degrade the A/D's performance in most cases. In effect, the ADC0820 does not "look" at the input when these transients occur. The comparators' outputs are not latched while  $\overline{WR}$  is Low, so at least 600ns will be provided to charge the ADC's input capacitance. It is

# 8-Bit, high-speed, $\mu$ P-compatible A/D converter with track/hold function

ADC0820

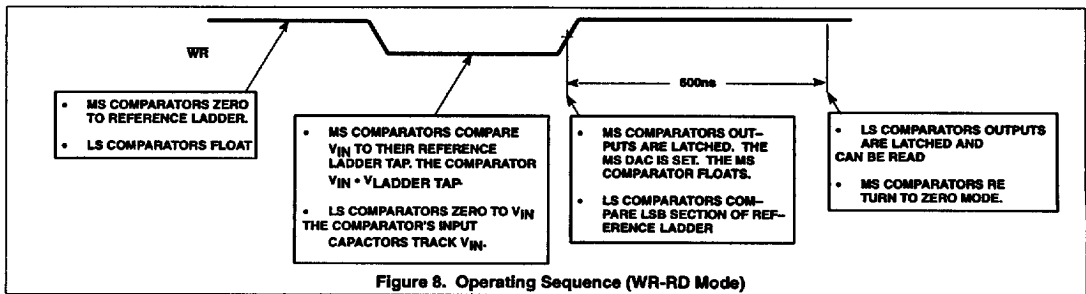


Figure 8. Operating Sequence (WR-RD Mode)

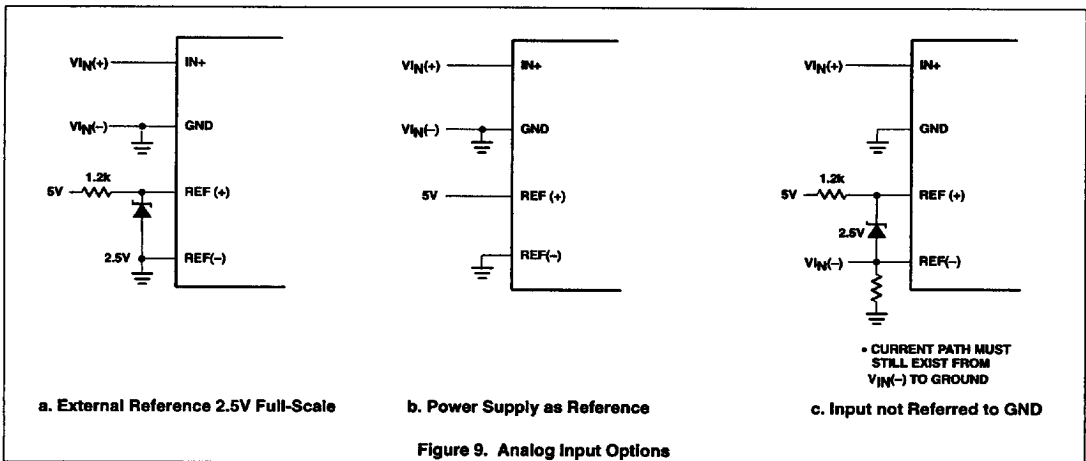


Figure 9. Analog Input Options

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ADC0820

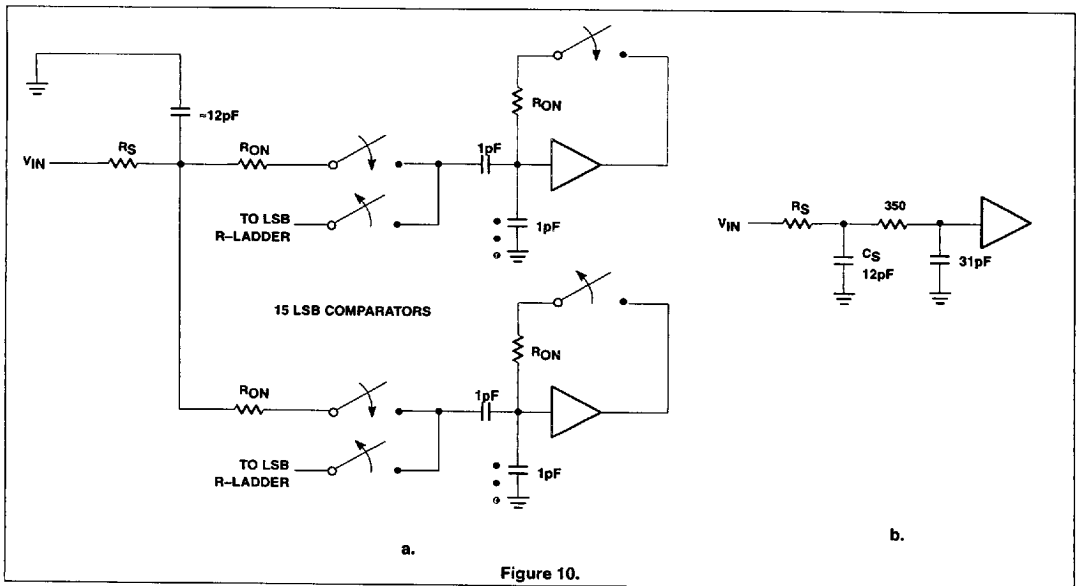


Figure 10.

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ADC0820

therefore not necessary to filter out these transients by putting an external cap on the  $V_{IN}$  terminal, if an input amplifier that can settle within 600ns is used to drive the input. The NE530 is a suitable op amp for driving the input of the ADC0820.

### Inherent Sample-Hold

Another benefit of the ADC0820's input mechanism is its ability to measure a variety of high-speed signals without the help of an external sample-and-hold. In a conventional SAR type converter, regardless of its speed, the input must remain at least 1/2LSB stable throughout the conversion process if full accuracy is to be maintained. Consequently, for many high-speed signals, this signal must be externally sampled, and held stationary during the conversion.

Sampled data comparators, by nature of their input switching, already accomplish this function to a large degree (Section 1.2). Although the conversion time for the ADC0820 is 1.5 $\mu$ s, the time through which  $V_{IN}$  must be 1/2LSB stable is much smaller. Since the MS flash ADC uses  $V_{IN}$  as its "compare" input and the LS ADC uses  $V_{IN}$  as its "zero" input, the ADC0820 only "samples"  $V_{IN}$  when  $WR$  is Low. Even though the two flashes are not done simultaneously, the analog signal is measured at one instant. The value of  $V_{IN}$  approximately 100ns after the rising edge of  $WR$  (100ns due to internal logic propagation delay) will be the measured value.

Input signals with slew rates typically below 100mV/ $\mu$ s can be converted without error. However, because of the input time constants, and charge injection through the opened comparator input switches, faster signals may cause errors. Still, the ADC0820's loss in accuracy for a given increase in signal slope is far less than what would be witnessed in a conventional successive approximation device. An SAR type converter with a conversion time as fast as 1 $\mu$ s would still not be able to measure a 5V, 1kHz sine wave without the aid of an external sample-and-hold. The ADC0820, with no such help, can typically measure 5V, 7kHz waveforms.

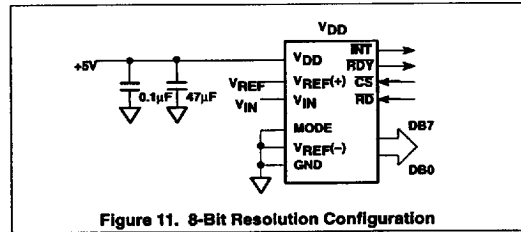


Figure 11. 8-Bit Resolution Configuration

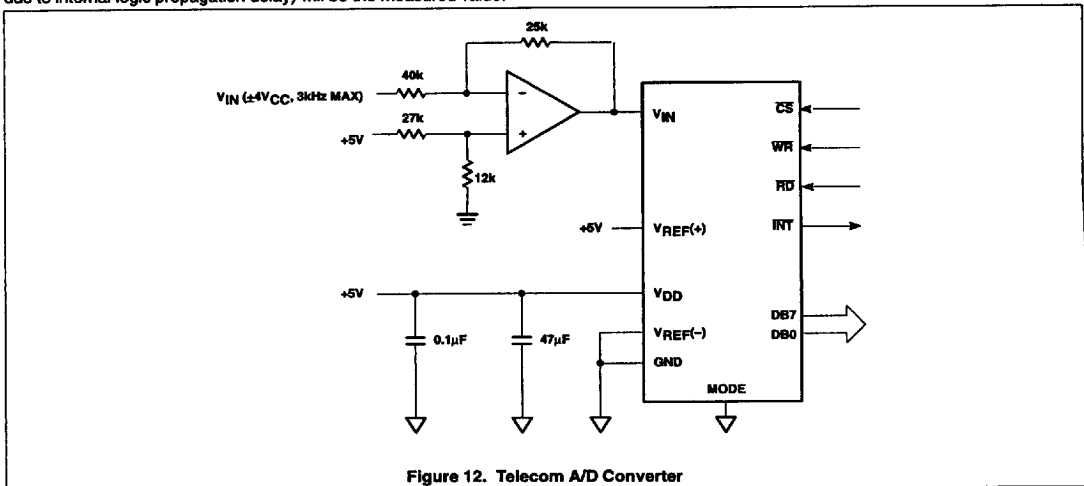


Figure 12. Telecom A/D Converter

# 8-Bit, high-speed, $\mu$ P-compatible A/D converter with track/hold function

## ADC0820

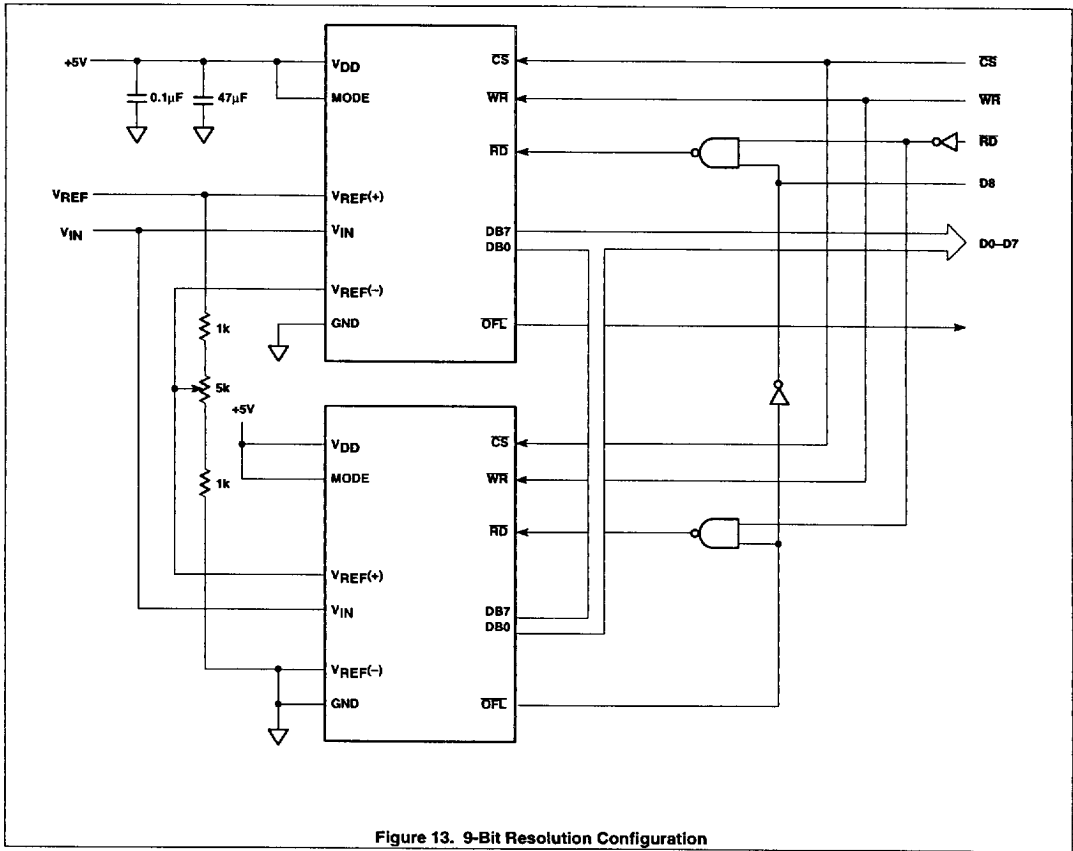


Figure 13. 9-Bit Resolution Configuration