

## FEATURES

- Monolithic CMOS
- Binary or BCD models
- 20 mW power consumption
- To 12-bit accuracy
- No missing codes
- Low cost

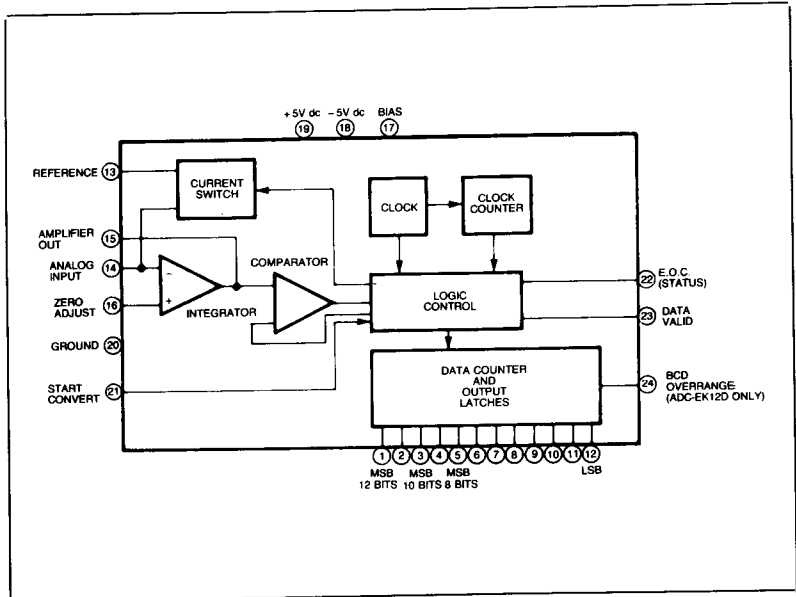
## GENERAL DESCRIPTION

The ADC-EK series are low power, integrating A/D converters fabricated on a single monolithic chip using CMOS technology. The circuit employs a charge balancing integrator, current switch, comparator, clock counter, data counter, and control logic circuitry to implement conversion. The charge balancing integration technique gives high linearity and noise immunity along with inherent monotonicity resulting in no missing codes. Output data appears in parallel form on latched outputs which are CMOS, low power TTL, or low power Schottky TTL compatible. The ADC-EK series consists of 5 different models with 8-, 10-, and 12-bit binary coding and 3½ digit BCD coding.

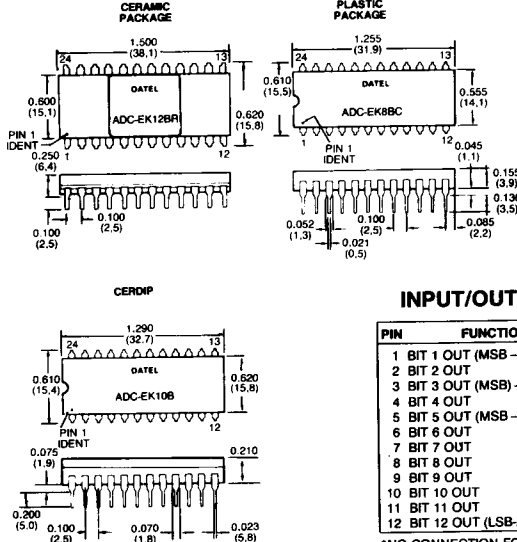
Conversion time is 1.8 to 24 milliseconds maximum depending on model. Nonlinearity is  $\pm 1/2$  LSB maximum while differential nonlinearity is  $\pm 1/4$  LSB typical. Other specifications include gain tempo of  $\pm 25$  ppm/°C typical and zero drift of  $\pm 50$   $\mu$ V/°C maximum. An external reference, integrating capacitor, and several other components are required for operation. The analog input voltage range is programmable by means of an external resistor which sets the current into the integrator at 10  $\mu$ A full scale. Standard operating mode is unipolar but bipolar operation is accomplished using an external op amp to provide an offset current from the reference.

Power requirement is  $\pm 5$ V dc at 2 mA, giving a power consumption of only 20 mW. The units are packaged in 24 pin ceramic or plastic DIP's.

**CAUTION:** The ADC-EK Series are CMOS devices and should be handled carefully to prevent static charge pickup which might damage the devices. The devices should be kept in the shipping containers until ready for installation.



## MECHANICAL DIMENSIONS INCHES (MM)



## INPUT/OUTPUT CONNECTORS

PIN	FUNCTION	PIN	FUNCTION
1	BIT 1 OUT (MSB - 12 BITS)	13	REFERENCE
2	BIT 2 OUT	14	ANALOG INPUT
3	BIT 3 OUT (MSB) - 10 BITS	15	AMPLIFIER OUT
4	BIT 4 OUT	16	ZERO ADJUST
5	BIT 5 OUT (MSB - 8 BITS)	17	BIAS
6	BIT 6 OUT	18	-5V POWER
7	BIT 7 OUT	19	+5V POWER
8	BIT 8 OUT	20	GROUND
9	BIT 9 OUT	21	START CONVERT
10	BIT 10 OUT	22	E.O.C. (STATUS)
11	BIT 11 OUT	23	DATA VALID
12	BIT 12 OUT (LSB-ALL)	24	BCD OVERRANGE*

\*NO CONNECTION FOR OTHER MODELS

**NOTE:**  
For 8- and 10-bit models, do not connect to unused data output terminals since they have internal connections.

ABSOLUTE MAXIMUM RATINGS	ADC-EK8B/ 10B/12B	ADC-EK12DC/ DR/DM
$I_{IN}$ .....	$\pm 10$ mA	
$I_{REF}$ .....	$\pm 10$ mA	
Digital Input Voltage .....	$-0.3V$ to $V_{DD} + 0.3V$	
$V_{DD} - V_{SS}$ .....	$18V$	
Package Dissipation .....	$500$ mW	

PHYSICAL/ENVIRONMENTAL	
Operating Temp. Range .....	See Ordering Information
Storage Temp. Range .....	$-65^{\circ}C$ to $+150^{\circ}C$
Package .....	24 Pin DIP

FOOTNOTES:	
1.	For the ADC-EK 12DM only. Initial gain error is $\pm 5\%$ . Gain. Tempco is $\pm 40$ ppm/ $^{\circ}C$ typical, $\pm 80$ ppm/ $^{\circ}C$ maximum and Zero Drift Tempco is $80 \mu V/^{\circ}C$ .
2.	ADC-EK 12DM outputs can sink and source $500 \mu A$ .
3.	Supply Sensitivity given for $V_{DD} = V_{SS} = 5V \pm 1V$ .

**FUNCTIONAL SPECIFICATIONS**

Typical at  $25^{\circ}C$ ,  $\pm 5V$  Supplies,  $R_{BIAS} = 100K$ , unless otherwise noted.

ANALOG INPUTS	
Type Analog Input .....	Single Ended
Full Scale Input Current .....	$+10 \mu A$
Reference Current .....	$-20 \mu A$
DIGITAL INPUTS	
Logical "1" $V_{IN}$ .....	$3.5V$ minimum
Logical "0" $V_{IN}$ .....	$1.5V$ maximum
Start Convert Pulse .....	$>3.5V$ for $500$ nanoseconds minimum
OUTPUTS	
Parallel Output Data .....	8, 10, 12 Lines   12 Lines and Overrange
Logic "1" Output Voltage .....	$+4.5V$ minimum at $-10 \mu A$ , $+2.4V$ minimum at $-360 \mu A^2$
Logic "0" Output Voltage .....	$+0.4$ maximum at $-360 \mu A^2$
E.O.C. (Status) .....	High During Conversion, Low When Completed
Data Valid .....	High When Data Valid, Low When Data Changing
PERFORMANCE	
Resolution .....	8, 10, 12 Bits   $3\frac{1}{2}$ Digits
Coding .....	Straight Binary   BCD
Nonlinearity .....	$\frac{1}{2}$ LSB, maximum   $0.025\%$ maximum
Differential Nonlinearity .....	$\frac{1}{4}$ LSB, typical, $\frac{1}{2}$ LSB maximum   $0.025\%$ maximum
Diff. Nonlinearity Tempco .....	$\pm 2.5$ ppm/ $^{\circ}C$ typical, $\pm 5$ ppm/ $^{\circ}C$ maximum
No Missing Codes .....	Over Operating Temperature Range
Initial Gain Error, Adj. to Zero .....	$+5, -3\%$ maximum <sup>1</sup>
Gain Temperature Coefficient .....	$\pm 25$ ppm/ $^{\circ}C$ typical, $\pm 75$ ppm/ $^{\circ}C$ maximum <sup>1</sup>
Initial Zero Error, Adj. to Zero .....	$\pm 50$ mV maximum
Zero Drift Tempco .....	$\pm 50 \mu V/^{\circ}C$ maximum <sup>1</sup>
Conversion Time, maximum .....	1.8 milliseconds   12 milliseconds (8 Bits)   (3 $\frac{1}{2}$ Digits) 6 milliseconds (10 Bits) 24 milliseconds (12 Bits)
Power Supply Sensitivity .....	$\pm 0.05\%$ of Full-Scale Gain <sup>3</sup>
POWER REQUIREMENTS	
Voltage, Rated Performance .....	$\pm 5V$ dc
Voltage Range, Operating .....	$\pm 3.5V$ dc to $\pm 7V$ dc
Supply Quiescent Current .....	
ADC-EK8B, EK12DC .....	$\pm 5.0$ mA
ADC-EK10B, EK12B, EK12DR .....	$\pm 2.5$ mA maximum
ADC-EK12DM .....	$\pm 3.5$ mA maximum

**TECHNICAL NOTES**

1. The ADC-EK series are CMOS devices and must be properly handled to prevent damage from static pick-up. Proper anti-static handling procedures should be observed including storage in conductive form or shorting all pins together with aluminum foil. Do not connect in circuits under "power on" conditions. The input voltage should be applied after power is on. Do not open circuits the zero adjust, reference, or start convert pins while power is on. It should also be noted that the top and bottom of the ceramic package are connected to the positive supply.
2. Nominal values of input, reference, and offset resistors are given in the resistor table. Due to the possible  $\pm 5\%$  tolerance of the external reference and  $+5\% -3\%$  tolerance on the converter scale factor, the actual resistor value can vary by almost  $\pm 10\%$ .  $R_G$  and  $R_T$  in the diagrams are for trimming gain and bipolar offset during calibration. It is recommended that  $R_G$  be  $1\%$  of  $R_{IN}$  (nominal) and  $R_T$  be  $1\%$  of  $R_{OFF}$  (nominal). They should both be  $100$  ppm/ $^{\circ}C$  cermet trimming pots. The recommended procedure for selecting  $R_{IN}$  and  $R_{OFF}$  is to set the  $R_G$  and  $R_T$  to center of range and then choose  $1\%$  metal film resistor which gives the nearest fit at the full scale point  $1111 \dots 111$  for  $R_{IN}$  and one that gives the nearest fit to zero scale point  $1000 \dots 000$  for  $R_T$ .
3. To choose any intermediate scale values for  $R_{IN}$  and  $R_T$  or values of  $R_{REF}$  for other reference voltages, use the following formulas:

$$R_{IN}(\text{nominal}) = \frac{FSR}{10 \mu A} \quad \text{FSR is the full scale range or total input voltage span for the converter.}$$

$$R_{OFF}(\text{nominal}) = \frac{V_{REF}}{5 \mu A}$$

$$R_{REF}(\text{nominal}) = \frac{V_{REF}}{20 \mu A}$$

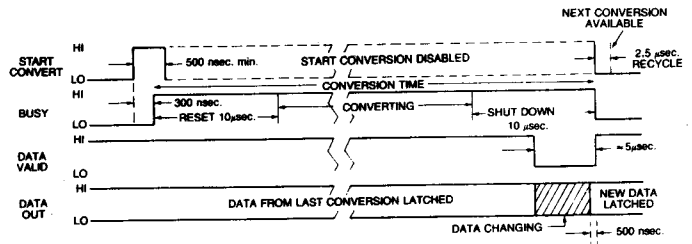
It is recommended that large full-scale voltage ranges be chosen such as  $0$  to  $+10V$ ,  $0$  to  $+5V$  etc., in order to keep the error due to input offset voltage drift to a minimum.

4. The temperature stability of the ADC-EK converters depends directly on the converter itself,  $R_{IN}$ ,  $R_{REF}$ ,  $R_{OFF}$ , and  $V_{REF}$ . Since the converter is typically  $\pm 20$  ppm/ $^{\circ}C$  it is recommended that a  $10$  ppm/ $^{\circ}C$  reference be used along with  $10$  ppm/ $^{\circ}C$  metal film resistors for  $R_{IN}$ ,  $R_{REF}$ , and  $R_{OFF}$  for best performance over temperature. On a statistical basis this would give about  $28$  ppm/ $^{\circ}C$  stability for the complete converter.

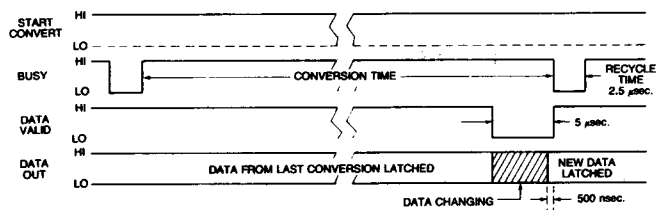
TECHNICAL NOTES (Cont'd)

5. Other passive components used with the converter may have tolerances as indicated here:  $R_C$  is a  $\pm 10\%$  carbon composition resistor;  $C_C$  is a  $\pm 20\%$  ceramic capacitor;  $C_{INT}$  is a  $\pm 10\%$  glass or ceramic capacitor;  $R_{BIAS}$  is a  $\pm 10\%$  carbon composition resistor; and the two zero adjust resistors are  $\pm 10\%$  carbon composition type. It is recommended that two  $0.1 \mu F$  bypass capacitors be used right at the power supply pins.  $C_{INT}$  should be connected as close as possible to pins 14 and 15 away from any noisy lines.
6. The start convert pulse initiates conversion on the low to high transition after which the conversion cycle cannot be interrupted and must run to completion.
7. Logic signals should not be routed under these devices or near the input reference, or zero adjust pins.
8. The unused data output pins on the 8- and 10-bit models should not be used for external connection points since they have internal connections to the converter.
9. All digital outputs will drive 2 low power TTL loads or 1 low power Schottky TTL load. They should not be overloaded as this will affect the performance of the converter.
10. Conversion accuracy is directly dependent on  $V_{REF}$ . In order to avoid degrading accuracy,  $V_{REF}$  voltage regulation must be  $\pm 0.04\%$  for 8 bit models,  $\pm 0.01\%$  for 10-bit models and  $\pm 0.0025\%$  for 12-bit models.

CLOCKED OPERATION



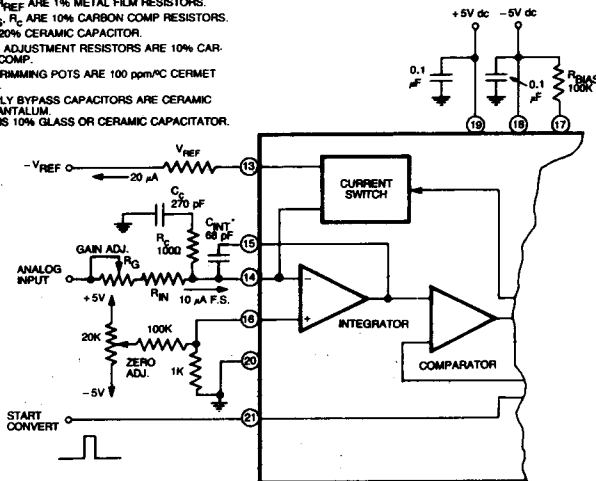
FREE RUNNING OPERATION



START CONVERT (PIN 21) IS TIED TO +5V dc (PIN 19).

CONNECTION FOR UNIPOLAR OPERATION

- $R_{IN}$ ,  $R_{REF}$  ARE 1% METAL FILM RESISTORS.
- $R_{BIAS}$ ,  $R_C$  ARE 10% CARBON COMP RESISTORS.
- $C_C$  IS 20% CERAMIC CAPACITOR.
- ZERO ADJUSTMENT RESISTORS ARE 10% CARBON COMP.
- ALL TRIMMING POTS ARE 100 ppm/°C CERMET TYPE.
- SUPPLY BYPASS CAPACITORS ARE CERAMIC OR TANTALUM.
- $C_{INT}$  IS 10% GLASS OR CERAMIC CAPACITATOR.



\*33 pF FOR ADC-EK88

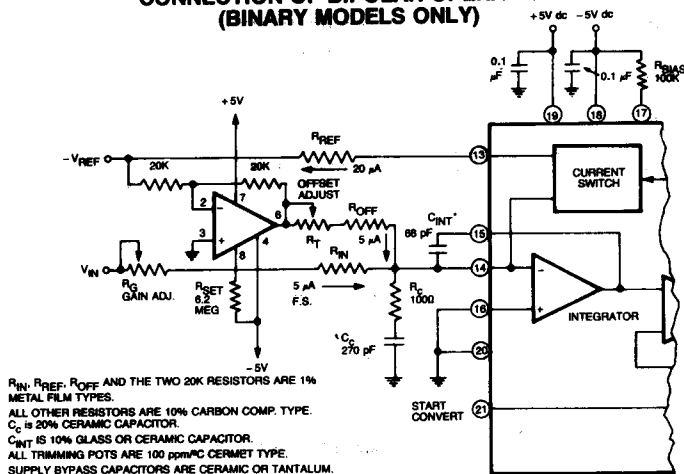
RESISTOR TABLES

UNIPOLAR RANGE	BIPOLAR RANGE	$R_{IN}$ (NOMINAL)
0 TO +2V	$\pm 1V$	200K
0 TO +5V	$\pm 2.5V$	500K
0 TO +10V	$\pm 5V$	1 MEG.
0 TO +20V	$\pm 10V$	2 MEG.

$V_{REF}$	$R_{REF}$ (NOMINAL)	$R_{OFF}$ (NOMINAL)
-1.22V	61K	244K
-2.5V	125K	500K
-6.4V	320K	1.28 MEG.

CONNECTIONS

CONNECTION OF BIPOLAR OPERATION  
(BINARY MODELS ONLY)



$R_{IN}$ ,  $R_{REF}$ ,  $R_{OFF}$  AND THE TWO 20K RESISTORS ARE 1% METAL FILM TYPES.  
ALL OTHER RESISTORS ARE 10% CARBON COMP. TYPE.  $C_{INT}$  IS 20% CERAMIC CAPACITOR.  
 $C_{INT}$  IS 10% GLASS OR CERAMIC CAPACITOR.  
ALL TRIMMING POTS ARE 100 ppm/°C CERMET TYPE.  
SUPPLY BYPASS CAPACITORS ARE CERAMIC OR TANTALUM.

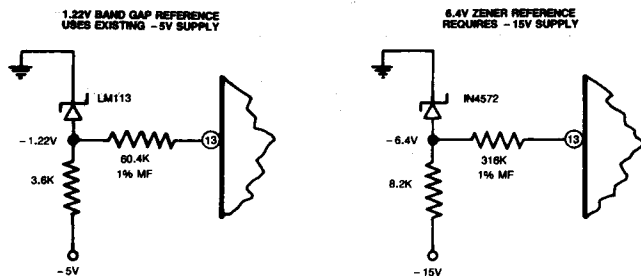
\*33 pF FOR ADC-EK8B

CALIBRATION PROCEDURE

1. Connect the converter as shown in the connection diagrams for either unipolar or bipolar operation. Determine the input voltage range and select the required input resistors. Apply a logic high to the start convert input (pin 21) to give free-running operation.
2. **Zero and Offset Adjustments.** Apply a precision voltage reference source from the analog input resistor to ground. Adjust the reference source to zero + 1/2 LSB for unipolar operation or -FS + 1/2 LSB for bipolar operation. Adjust the zero or offset potentiometer so that the output code flickers between 000...000 and 000...001.
3. **Gain Adjustment.** Set the output of the reference source to +FS - 1/2 LSB and adjust the gain trimming potentiometer so that the output code just flickers between 111...110 and 111...111.

For BCD coding the output code should flicker between 1001 1001 1000 and 1001 1001 1001.

REFERENCE CIRCUITS



CODING TABLES

STRAIGHT BINARY

SCALE	9-BIT		10-BIT		12-BIT	
	0 TO +10V	CODE	0 TO +10V	CODE	0 TO +10V	CODE
FS - 1 LSB	+9.96V	1111 1111	+9.960V	11 1111 1111	+9.9976V	1111 1111 1111
1/2 FS	+5.00	1000 0000	+5.000	10 0000 0000	+5.0000	1000 0000 0000
1 LSB	+0.04	0000 0001	+0.010	00 0000 0001	+0.0024	0000 0000 0001
0	0.00	0000 0000	0.000	00 0000 0000	0.0000	0000 0000 0000

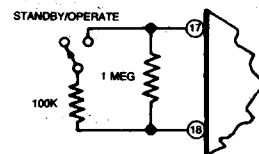
OFFSET BINARY

SCALE	±5V		±5V		±5V	
	±5V	CODE	±5V	CODE	±5V	CODE
+FS - 1 LSB	+4.96V	1111 1111	+4.960V	11 1111 1111	+4.9976V	1111 1111 1111
0	0.00	1000 0000	0.000	10 0000 0000	0.0000	1000 0000 0000
-FS + 1 LSB	-4.96	0000 0001	-4.960	00 0000 0001	-4.9976	0000 0000 0001
-FS	-5.00	0000 0000	-5.000	00 0000 0000	-5.0000	0000 0000 0000

BCD

SCALE	FULL SCALE RANGE			CODE
	0 TO +2V	0 TO +10V	0 TO +20V	
FS - 1 LSB	+1.999V	+9.995V	+19.990V	1 1001 1001 1001
1/2 FS	+1.000	+5.000	+10.000	1 0000 0000 0000
1 LSB	+0.001	+0.005	+0.010	0 0000 0000 0001
0	0.000	0.000	0.000	0 0000 0000 0000

REDUCTION OF STAND-BY POWER



THIS REDUCES POWER CONSUMPTION TO ABOUT 200 µA DURING STANDBY.

ORDERING INFORMATION

MODEL NO.	OPER. TEMP. RANGE	PACKAGE
<b>BINARY</b>		
ADC-EK8B	0°C to +70°C	Plastic
ADC-EK10B	-25°C to +85°C	Cerdip
ADC-EK12B	-25°C to +85°C	Ceramic

BCD

ADC-EK12DC	0°C to +70°C	Plastic
ADC-EK12DR	-25°C to +85°C	Ceramic
ADC-EK12DM	-55°C to +125°C	Ceramic

THESE CONVERTERS ARE COVERED UNDER GSA CONTRACT