DAC-02/DAC-03/DAC-05

10-BIT-PLUS-SIGN VOLTAGE-OUTPUT D/A CONVERTERS

Precision Monolithics Inc.

FEATURES

- **Complete** ..... **Includes Reference and Op Amp**
- **Compact** ..... **Single 18-Pin DIP Package**
- **Bipolar Output** ..... **(±10V) Sign-Magnitude Coding**
- **DAC-03 — Unipolar Only;** ..... **+5V or +10V**
- **Monotonicity Guaranteed**
- **Nonlinearity** ..... **±1 LSB**
- **Fast** ..... **2.0μs Settling Time**
- **Stable** ..... **Full-Scale Tempco 60ppm/°C**
- **Low Power Consumption** ..... **300mW Max**
- **TTL, CMOS Compatible Inputs**
- **MIL-STD-883 Class B Processing Available on DAC-05**

ORDERING INFORMATION †

MONOTONICITY BITS	PACKAGE: 18-PIN HERMETIC DIP			
	MILITARY TEMP*	COMMERCIAL TEMP		
10	DAC05AX	DAC02ACX	DAC03ADX	DAC05EX
8	——	DAC02CCX	DAC03CDX	——
7	——	DAC02DDX	——	——

*For devices processed in total compliance to MIL-STD-883, add /883 after part number. Consult factory for 883 data sheet.

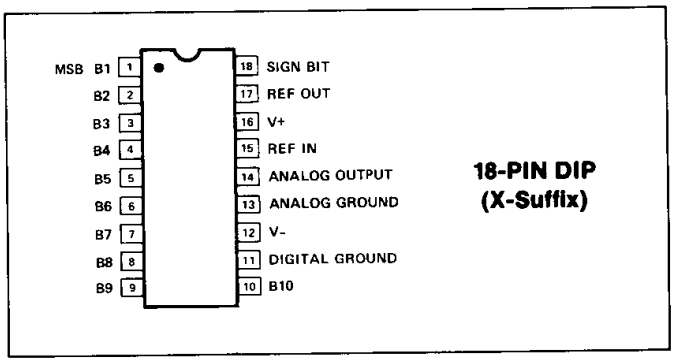
†Burn-in is available on commercial and industrial temperature range parts in cerdip, plastic dip, and TO-can packages. For ordering information, see 1988 Data Book, Section 2.

GENERAL DESCRIPTION

The DAC-02 and DAC-05 are complete 10-bit plus sign D/A converters on a single monolithic chip. All elements of a complete sign-magnitude DAC are included; precision voltage reference, current steering logic, current sources, R-2R resistor network, logic-controlled polarity switch, and high speed internally-compensated output op amp. Monotonicity guaranteed over the entire temperature range is achieved using an untrimmed diffused R-2R resistor network. The buffered reference input is capable of tracking over a wide range of voltages, increasing application flexibility. The wide power supply range, low power consumption, wide logic input compatibility and sign-magnitude coding assures utility in a wide range of applications including CRT displays, data acquisition systems, A/D converters, servo positioning controls, and audio digitizing/reconstruction systems.

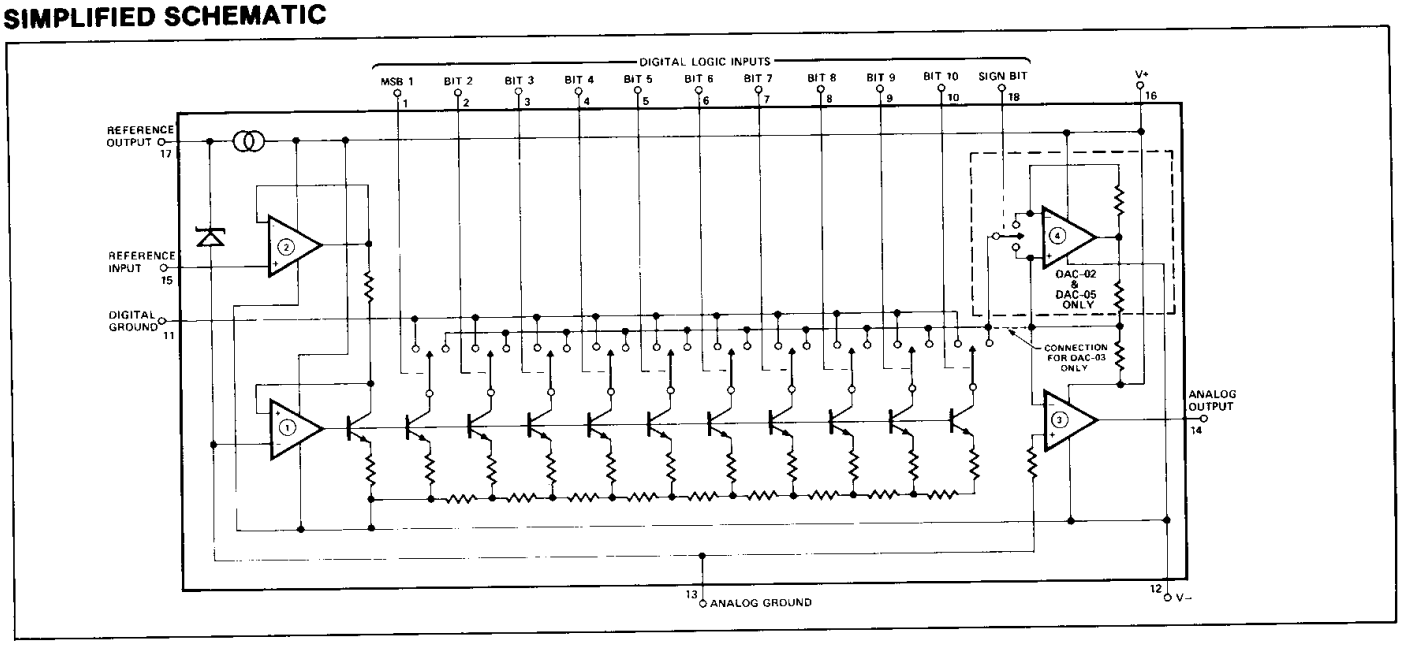
The DAC-03 is similar in construction to the DAC-02/DAC-05 except for a unipolar only output. This device is intended for low cost, limited temperature range applications, with the same general specifications as its premium counterparts.

PIN CONNECTIONS



18-PIN DIP (X-Suffix)

SIMPLIFIED SCHEMATIC



ABSOLUTE MAXIMUM RATINGS (Note)

Operating Temperature Range
DAC-05A ..... −55°C to +125°C
DAC-02 and DAC-03, All
DAC-05E ..... 0°C to +70°C
Storage Temperature Range ..... −65°C to +150°C
V+ Supply to Analog Ground ..... 0 to +18V
V− Supply to Analog Ground ..... 0 to −18V
Analog Ground to Digital Ground ..... 0 to ±0.5V
Logic Inputs to Digital Ground ..... −5V to (V + −0.7V)
Internal Reference Output Current 300μA
Reference Input Voltage ..... 0 to +10V
Internal Power Dissipation 500mW
Lead Temperature (Soldering, 60 sec) ..... 300°C
Output Short-Circuit Duration ..... Indefinite
(Short circuit may be to ground or either supply.)

NOTE: For ambient temperatures above 100°C derate 100mW/°C.

OUTPUT VOLTAGE RANGE SELECTION TABLE

PRODUCT	OUTPUT VOLTAGE RANGE	ADD AS SUFFIX TO PART NO.
DAC02	±10V	1
DAC03	0 to +10V	1
DAC03	0 to +5V	2
DAC05	±10V	1

ELECTRICAL CHARACTERISTICS at V_S = ±15V, 0 ≤ T_A ≤ +70°C for DAC-02 and DAC-05E, T_A = 25°C for DAC-03 and −55 ≤ T_A ≤ +125°C for DAC-05A, unless otherwise noted.

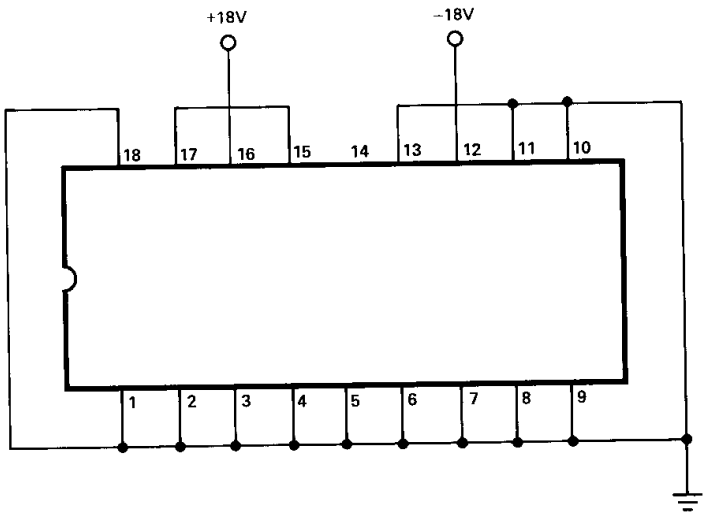
PARAMETER	SYMBOL	CONDITIONS	DAC-02	DAC-03	DAC-05	MIN	TYP	MAX	UNITS
Monotonicity			AC	AD	A/E	10	—	—	Bits
			CC	CD		8	—	—	
			DD			7	—	—	
Nonlinearity	NL		AC	AD		—	—	±0.1	% FS
			CC	CD	A/E	—	—	±0.2	
			DD			—	—	±0.4	
Full-Scale Tempco	T_C	INT REF	AC/CC	ALL	A	—	—	±60	ppm/°C
						—	±60	—	
					E	—	±45	±100	
			DD			—	—	±150	
		EXT REF	ALL	ALL	ALL	—	±30	—	ppm/°C
						—	±40	—	
Settling Time	t_S	To 1/2 LSB, 10V Step (Note 4)	ALL	ALL	ALL	—	2	—	μs
Full Range Output Voltage (Note 1)	V_{FR}	V_{FR+} (SB High)	ALL		ALL	+10	—	+11.5	Volts
		V_{FR-} (SB Low)	ALL		ALL	−11.5	—	−10	
		DAC-03 +10V		ALL		+10	—	+11.5	
		+5V		ALL		+5.00	—	+5.75	
Zero-Scale Offset	V_{ZS}	SB High. All other logic inputs low. T_A = 25°C			ALL	—	±1	±5	mV
				ALL		—	±1	±10	
			ALL			—	±5	±10	
		T_A = Min or Max	ALL		ALL	—	±2	±10	mV
Zero-Scale Symmetry	V_{ZSS}	(Note 2)	AC/CC			—	±1	±5	mV
			DD	N/A		—	±1	±10	
					ALL	—	±4	±10	
Full Range Bipolar Symmetry	V_{FRS}	$V_{FR+} - \lvert V_{FR-} \rvert$ (Note 3)	AC/CC	N/A		—	±30	±60	mV
			DD			—	±30	±80	
		T_A = Min or Max			ALL	—	±20	±70	mV
		T_A = 25°C			ALL	—	±10	±50	mV
Reference Input Bias Current	I_B		ALL	ALL	ALL	—	100	—	nA
Reference Input Impedance	Z_{IN}		ALL	ALL	ALL	—	200	—	MΩ
Reference Input Slew Rate	SR		ALL	ALL	E	—	1.5	—	V/μs
					A	—	2	—	
Reference Output Voltage	V_{REF}		ALL	ALL	ALL	—	6.7	—	Volts
Logic Input Current	I_{IN}	Each input −5V to (V+ − 0.7)V	ALL	ALL	ALL	—	±1	±10	μA
Logic Input 0	V_{INL}		ALL	ALL	ALL	—	—	0.8	Volts
Logic Input 1	V_{INH}		ALL	ALL	ALL	2	—	—	

ELECTRICAL CHARACTERISTICS at $V_S = \pm 15V$, $0 \leq T_A \leq +70°C$ for DAC-02 and DAC-05E, $T_A = 25°C$ for DAC-03 and $-55 \leq T_A \leq +125°C$ for DAC-05A, unless otherwise noted. (Continued)

PARAMETER	SYMBOL	CONDITIONS	DAC-02	DAC-03	DAC-05	MIN	TYP	MAX	UNITS
Positive Supply Current	I+	SB High. All other logic inputs low.	AC/CC		ALL	—	+7	+10	mA
			DD	ALL		—	+7	+11.6	
Negative Supply Current	I−	SB High. All other logic inputs low.	AC/CC		ALL	—	−9	−10	mA
			DD			—	−9	−11.6	
				ALL		—	−10	−11.6	
Power Supply Sensitivity	P_{SS}	$V_S = \pm 12$ to $\pm 18V$	AC/CC			—	±0.015	±0.05	% V_{FS}/V
			DD	ALL		—	±0.015	±0.1	
		T_A = Min to Max			ALL	—	±0.05	±0.1	
		$T_A = 25°C$			ALL	—	±.02	±.05	
Power Dissipation	P_d	$I_{OUT} = 0$	AC/CC			—	225	300	mW
			DD	ALL		—	225	350	
		$T_A = 25°C$			ALL	—	200	300	
		T_A = Min to Max			ALL	—	250	350	
Output Drive Current	I_O	Guaranteed by V_{FR} test	ALL	ALL	ALL	—	—	5	mA

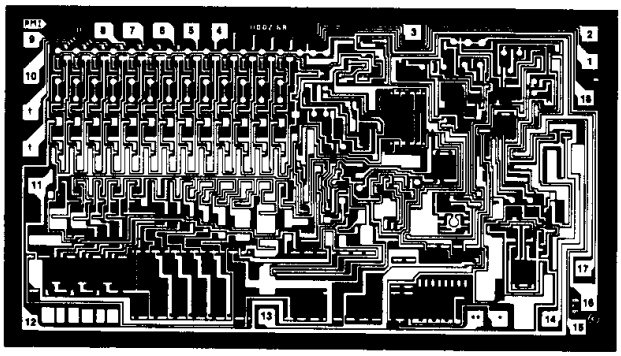
NOTES:
1. Reference output terminal connected directly to reference input terminal, $R_L = 2k\Omega$ for 10V devices, $R_L = 1k\Omega$ for 5V devices, all logic inputs ≥ 2.0V.
2. Zero-scale symmetry is the change in the output voltage produced by switching the sign-bit with all logic bits low ($V_{ZS+} - V_{ZS-}$).
3. Full-scale bipolar symmetry is the magnitude of the difference between V_{FR+} and $|V_{FR-}|$.
4. Guaranteed by design.

BURN-IN CIRCUIT



NOTE : PINS 14, 15, & 17 MUST NOT BE CONNECTED TO A COMMON BUS BETWEEN DEVICES.

DICE CHARACTERISTICS



DIE SIZE 0.162 × 0.090 inch; 14,580 sq. mils
(4.114 × 2.286 mm, 9.405 sq. mm)

1. BIT 1-MSB
2. BIT 2
3. BIT 3
4. BIT 4
5. BIT 5
6. BIT 6
7. BIT 7
8. BIT 8
9. BIT 9
10. BIT 10
11. DIGITAL GROUND
12. V–
13. ANALOG GROUND
14. ANALOG OUTPUT
15. REF IN
16. V+
17. REF OUT
18. SIGN BIT

For additional DICE ordering information, refer to 1988 Data Book, Section 2.

NOTE:
Voltage output range programmable by connecting *(10V) to analog output for 10 volt range. Jumps from **(5V) to analog output for 5 volt range. †Bits 11 & 12 (not normally used)

WAFER TEST LIMITS at $V_S = \pm 15V$, $T_A = 25°C$ and +10V full-scale output, unless otherwise noted.

PARAMETER	CONDITIONS	DAC-02-N LIMIT	DAC-02-G LIMIT	UNITS
Resolution (Bits 11 and 12 Not Normally Used)	Bipolar Output Unipolar Output	13 12	13 12	Bits MAX
Monotonicity		9	8	Bits MIN
Nonlinearity		±0.1	±0.2	% FS MAX
Zero-Scale Offset	Sign Bit High, All Other Inputs Low	±10	±10	mV MAX
Zero-Scale Symmetry	±10V Full-Scale	±5	±5	mV MAX
Full-Scale Bipolar Symmetry	±10V Full-Scale	±60	±60	mV MAX
Power Supply Rejection	$V_S = \pm 12V$ to ±18V	0.05	0.05	$\%V_{FS}/V$ MAX
Power Dissipation	$I_{OUT} = 0$	300	300	mW MAX
Logic Input "0"		0.8	0.8	V MAX
Logic Input "1"		2	2	V MIN
Full Range Output Voltage	Sign-Bit High or Low	±11.5 ±10	±11.5 ±10	V MAX V MIN

NOTE:
Electrical tests are performed at wafer probe to the limits shown. Due to variations in assembly methods and normal yield loss, yield after packaging is not guaranteed for standard product dice. Consult factory to negotiate specifications based on dice lot qualification through sample lot assembly and testing.

TYPICAL ELECTRICAL CHARACTERISTICS at $V_S = \pm 15V$ and +10V full-scale output, unless otherwise noted.

PARAMETER	SYMBOL	CONDITIONS	DAC-02-N TYPICAL	DAC-02-G TYPICAL	UNITS
Full-Scale Tempco	TCV_{FS}	Internal Reference	60	60	ppm/°C
Settling Time ($T_A = 25°C$)	t_s	To ±1/2 LSB 10 Volt Step	2	2	µs
Logic Input Current	I_{IN}	$T_A = 25°C$	1	1	µA

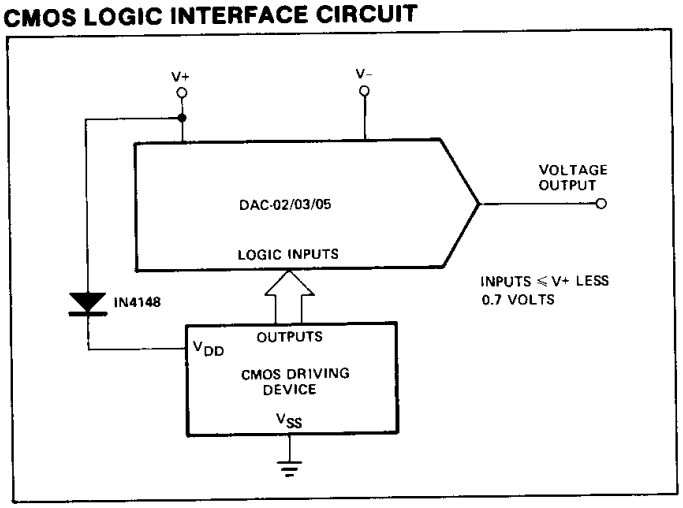
NOTE:
When ordering DICE in this series, use DAC-02 numbers and grades above.

TYPICAL APPLICATIONS

The DAC-02's, DAC-03's and DAC-05's logic input stages require about 1μA and are capable of operation with inputs between −5 volts and V+ less 0.7 volt. This wide input voltage range allows direct CMOS interfacing in most applications, the exception being where the CMOS logic and D/A converter must use the same positive power supply.

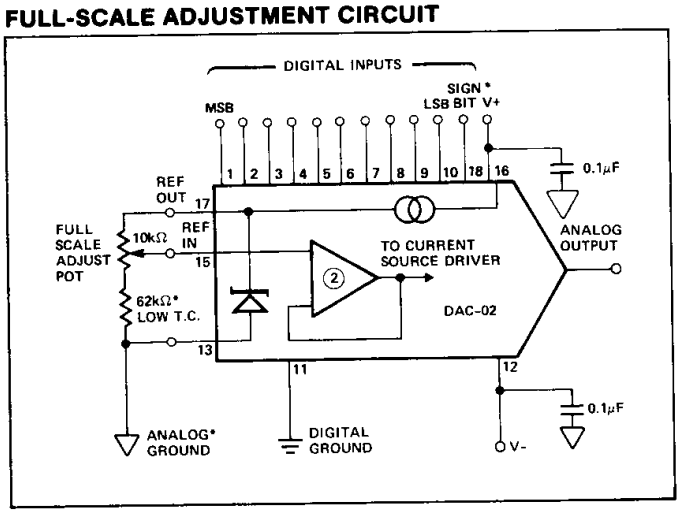
In this special case, a diode should be placed in series with the CMOS driving device's V_{DD} lead as shown in Figure 1. The diode limits V_D to V+ less 0.7 volt — since the output from the CMOS device cannot exceed this value, the DAC's maximum input voltage rule is satisfied. Summarizing: in all applications, the DAC-02, DAC-03 and DAC-05 require either no interfacing components, or at most a single inexpensive diode for full CMOS compatibility.

CMOS LOGIC INTERFACE CIRCUIT



CONNECTION INFORMATION

FULL-SCALE ADJUSTMENT CIRCUIT



FULL-SCALE ADJUSTMENT

Full-scale output voltage may be trimmed by use of a potentiometer and series resistor as shown; however, best results will be obtained if a low tempco resistor is used or if pot and resistor tempcos match. Alternatively, a single pot of ≤72kΩ may be used.

REFERENCE INPUT BYPASS

Lowest noise and fastest settling operation will be obtained by bypassing the reference input to analog ground with a 0.01μF disk capacitor.

GROUNDING

For optimum noise rejection, separate digital and analog grounds have been brought out. Best results will be obtained if these grounds are connected together at one point only, preferably near the DAC-02, DAC-03 and DAC-05 package, so that the large digital currents do not flow through the analog ground path.

APPLICATIONS INFORMATION

LOWER RESOLUTION APPLICATIONS

For applications not requiring full 10-bit resolution, unused logic inputs should be tied to ground.

UNIPOLAR OPERATION

Operation as a 10-bit straight binary converter may be implemented by permanently tying the sign-bit to +5V (for positive full-scale output) or to ground (for negative full-scale output). In the DAC-03 only, Pin 18 unipolar enable is tied to Pin 17.

POWER SUPPLIES

The DAC-02, DAC-03 and DAC-05 will operate within specifications for power supplies ranging from ±12V to ±18V. Power supplies should be bypassed near the package with a 0.1μF disk capacitor.

CAPACITIVE LOADING

The output operational amplifier provides stable operation with capacitive loads up to 100pF.

REFERENCE OUTPUT

For best results, reference output current should not exceed 100μA.

USE WITH EXTERNAL REFERENCES

Positive-polarity external reference voltages referred to analog ground may be applied to the reference input terminal to improve full-scale tempco, to provide tracking to other system elements, or to slave a number of DAC-02's, DAC-03's and DAC-05's to the reference output of any one of them. This reference voltage should be between +5V to +7V for optimum performance.

SIGN PLUS MAGNITUDE CODING TABLE (DAC-02, DAC-03 and DAC-05)

	SIGN-BIT	MSB									LSB
+ FULL SCALE	1	1	1	1	1	1	1	1	1	1	1
+ HALF-SCALE	1	1	0	0	0	0	0	0	0	0	0
ZERO-SCALE (+)	1	0	0	0	0	0	0	0	0	0	0
ZERO-SCALE (−)	0	0	0	0	0	0	0	0	0	0	0
− HALF-SCALE	0	1	0	0	0	0	0	0	0	0	0
− FULL-SCALE	0	1	1	1	1	1	1	1	1	1	1