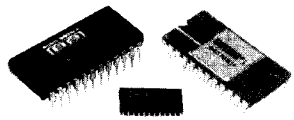
BURR-BROWN®



DAC700/702
DAC701/703

MILITARY VERSION AVAILABLE

Monolithic 16-Bit DIGITAL-TO-ANALOG CONVERTERS

FEATURES

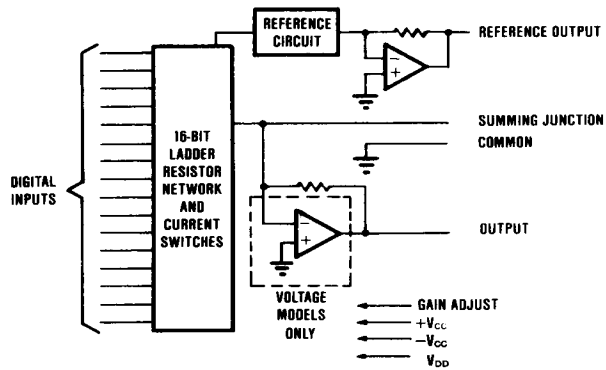
- MONOLITHIC CONSTRUCTION
- V_{OUT} AND I_{OUT} MODELS
- HIGH ACCURACY:
  Linearity Error ±0.0015% of FSR max
  Differential Linearity Error ±0.003% of FSR max
- MONOTONIC (at 15 bits) OVER FULL SPECIFICATION TEMPERATURE RANGE
- PIN-COMPATIBLE WITH DAC70, DAC71, DAC72
- LOW COST
- DUAL-IN-LINE PLASTIC AND HERMETIC CERAMIC
- /QM ENVIRONMENTAL SCREENING AVAILABLE
- BURN-IN PROGRAM AVAILABLE (-BI)

DESCRIPTION

This is another industry first from Burr-Brown—a complete 16-bit digital-to-analog converter that includes a precison buried-zener voltage reference and a low-noise, fast-settling output operational amplifier (voltage output models), all on one small monolithic chip. A combination of current-switch design techniques accomplishes not only 15-bit monotonicity over the entire specified temperature range but also a maximum end-point linearity error of ±0.0015% of full-scale range. Total full-scale gain drift is limited to ±10ppm/°C maximum (LH and CH grades).

Digital inputs are complementary binary coded and are TTL-, LSTTL-, 54/74C- and 54/74HC-compatible over the entire temperature range. Outputs of 0 to +10V, ±10V, 0 to −2mA, and ±1mA are available.

These D/A converters are packaged in hermetic 24-pin ceramic side-brazed or molded plastic. The DIP-packaged parts are pin-compatible with the voltage and current output DAC71 and DAC72 model families. The DAC700 and DAC702 are also pin-compatible with the DAC70 model family. In addition, the DAC703 is offered in a 24-pin SOIC package for surface mount applications.



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SPECIFICATIONS

ELECTRICAL

At T_A = +25°C and rated power supplies unless otherwise noted.

MODEL	DAC702/703J			DAC700/701/702/703K			DAC700/701/702/703B, S			DAC700/701/702/703L, C			
PARAMETER	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNITS
INPUT													
DIGITAL INPUT													
Resolution			16			*			*			*	Bits
Digital Inputs[1]													
V_{IH}	+2.4		$+V_{CC}$	*		*	*		*	*		*	V
V_{IL}	−1.0		+0.8	*		*	*		*	*		*	V
I_{IH}, V_I = +2.7V			+40			*			*			*	µA
I_{IL}, V_I = +0.4V		−0.35	−0.5		*	*		*	*		*	*	mA
TRANSFER CHARACTERISTICS													
ACCURACY[2]													
Linearity Error[4]		±0.0015	±0.006		*	±0.003		*	*		±0.00075	±0.0015	% of FSR[3]
Differential Linearity Error[4]		±0.003	±0.012		*	±0.006		*	*		±0.0015	±0.003	% of FSR
Differential Linearity Error at Bipolar Zero (DAC702/703)[4]					±0.003	±0.006		±0.0015	±0.003		*	*	% of FSR
Gain Error[5]		±0.07	±0.30		*	±0.15		±0.05	±0.10		*	*	%
Zero Error[5,6]		±0.05	±0.10		*	*		*	*		*	*	% of FSR
Monotonicity Over Spec. Temp. Range	13			14			*			15			Bits
DRIFT (over specification temperature range)													
Total Error Over Temperature Range (all models)[7]		±0.08			*	±0.15		±0.05	±0.10		*	*	% of FSR
Total Full Scale Drift:													
DAC700/701		±10			*	±30		±8.5	±18		±6	±13	ppm of FSR/°C
DAC702/703		±10			*	±25		±7	±15		*	*	ppm of FSR/°C
Gain Drift (all models)		±10	±30		*	±25		±7	±15		±5	±10	ppm/°C
Zero Drift:													
DAC700/701					±2.5	±5		±1.5	±3		*	*	ppm of FSR/°C
DAC702/703		±5	±15		*	±12		±4	±10		±2.5	±5	ppm of FSR/°C
Differential Linearity Over Temp.[4]			±0.012			+0.009, −0.006			*			+0.006, −0.003	% of FSR
Linearity Error Over Temp.[4]			±0.012			±0.006			*			±0.003	% of FSR
SETTLING TIME (to ±0.003% of FSR)[8]													
DAC701/703 (V_{OUT} models)													
Full Scale Step, 2kΩ load		4			*	8		*	*		*	*	µsec
1LSB Step at Worst-Case Code[9]		2.5			*			*			*		µsec
Slew Rate		10			*			*			*		V/µsec
DAC700/702 (I_{OUT} models)													
Full Scale Step (2mA), 10 to 100Ω load		350			*	1000		*	*		*	*	nsec
1kΩ load		1			*	3		*	*		*	*	µsec
OUTPUT													
VOLTAGE OUTPUT MODELS													
DAC701 (CSB Code)					0 to +10			*					V
DAC703 (COB Code)		±10			*			*			*		V
Output Current	±5			*			*			*			mA
Output Impedance		0.15			*			*			*		Ω
Short Circuit to Common Duration		Indefinite			*			*			*		
CURRENT OUTPUT MODELS													
DAC700 (CSB Code)[10]					0 to −2			*			*		mA
Output Impedance[10]					4			*			*		kΩ
DAC702 (COB Code)[10]		±1			*			*			*		mA
Output Impedance[10]		2.45			*			*			*		kΩ
Compliance Voltage		±2.5			*			*			*		V

ELECTRICAL (CONT)

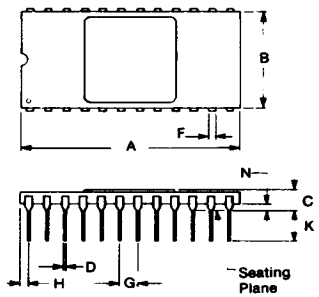
MODEL	DAC702/703J			DAC700/701/702/703K			DAC700/701/702/703B, S			DAC700/701/702/703L, C			UNITS
PARAMETER	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
REFERENCE VOLTAGE													
Voltage		+6.3		+6.0	+6.3	+6.6	+6.24	+6.3	+6.36	*	*	*	V
Source Current Available for External Loads		+2.5		+1.5	*		*	*		*	*		mA
Temperature Coefficient		±10			*	±25		*	±15		*	*	ppm/°C
Short Circuit to Common Duration		Indefinite			*			*			*		
POWER SUPPLY REQUIREMENTS													
Voltage: $+V_{CC}$	13.5	15	16.5	*	*	*	*	*	*	*	*	*	V
$-V_{CC}$	13.5	15	16.5	*	*	*	*	*	*	*	*	*	V
V_{DD}	+4.5	+5	+16.5	*	*	*	*	*	*	*	*	*	V
Current (no load):													
DAC700/702													
(I_{OUT} models)													
$+V_{CC}$		+10			*	+25		*	*		*	*	mA
$-V_{CC}$		−13			*	−25		*	*		*	*	mA
V_{DD}		+4			*	+8		*	*		*	*	mA
DAC701/703													
(V_{OUT} models)													
$+V_{CC}$		+16			*	+30		*	*		*	*	mA
$-V_{CC}$		−18			*	−30		*	*		*	*	mA
V_{DD}		+4			*	+8		*	*		*	*	mA
Power Dissipation:													
(V_{DD} = +5.0V)[11]													
DAC700/702		365			*	790		*	630		*	*	mW
DAC701/703		530			*	940		*	780		*	*	mW
Power Supply Rejection:													
$+V_{CC}$		±0.0015	±0.006		*	*		*	±0.003		*	*	% of FSR/%V_{CC}
$-V_{CC}$		±0.0015	±0.006		*	*		*	±0.003		*	*	% of FSR/%V_{CC}
V_{DD}		±0.0001	±0.001		*	*		*	*		*	*	% of FSR/%V_{DD}
TEMPERATURE RANGE													
Specification:													
B, C grades							−25		+85	*		*	°C
S grades							−55		+125				°C
J, K, L grades	0		+70	*		*				0		+70	°C
Storage: Ceramic				−60		+150	*		*	*		*	°C
Plastic, SOIC	−60		+100	*		*							°C

*Specification same as model to the left.

NOTES. (1) Digital inputs are TTL, LSTTL, 54/74C, 54/74HC, and 54/74HTC compatible over the operating voltage range of V_{DD} = +5V to +15V and over the specified temperature range. The input switching threshold remains at the TTL threshold of 1.4V over the supply range of V_{DD} = +5V to +15V. As logic "0" and logic "1" inputs vary over 0V to +0.8V and +2.4V to +10V respectively, the change in the D/A converter output voltage will not exceed ±0.0015% of FSR for the LH and CH grades, ±0.003% of FSR for the BH grade and ±0.006% of FSR for the KG grade. (2) DAC700 and DAC702 (current-output models) are specified and tested with an external output operational amplifier connected using the internal feedback resistor in all parameters except settling time. (3) FSR means full-scale range and is 20V for the ±10V range (DAC703), 10V for the 0 to +10V range (DAC701). FSR is 2mA for the ±1mA range (DAC700) and the 0 to +2mA range (DAC702). (4) ±0.0015% of full-scale range is equivalent to 1LSB in 15-bit resolution. ±0.003% of full-scale range is equivalent to 1LSB in 14-bit resolution. ±0.006% of full-scale range is equivalent to 1LSB in 13-bit resolution. (5) Adjustable to zero with external trim potentiometer. Adjusting the gain potentiometer rotates the transfer function around the zero point. (6) Error at input code $FFFF_H$ for DAC700 and DAC701, $7FFF_H$ for DAC702 and DAC703. (7) With gain and zero errors adjusted to zero at +25°C. (8) Maximum represents the 3σ limit. Not 100% tested for this parameter. (9) At the major carry, $7FFF_H$ to 8000_H and 8000_H to $7FFF_H$. (10) Tolerance on output impedance and output current is ±30%. (11) Power dissipation is an additional 40mW when V_{DD} is operated at +15V.

MECHANICAL

H Package

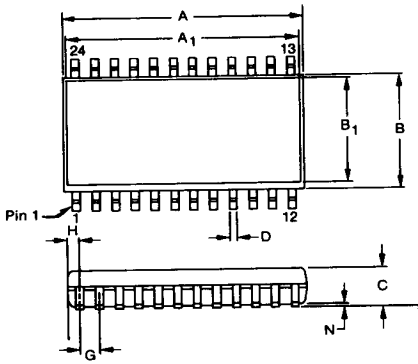


DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	1.185	1.215	30.10	30.86
B	.600	.620	15.24	15.75
C	.125	.171	3.18	4.34
D	.015	.021	0.38	0.53
F	.035	.060	0.89	1.52
G	.100 BASIC		2.54 BASIC	
H	.030	.070	0.76	1.78
J	.008	.012	0.20	0.30
K	.120	.240	3.05	6.10
L	.600 BASIC		15.24 BASIC	
M	—	10°	—	10°
N	.025	.060	0.64	1.52

NOTE: Leads in true position within .010" (.25mm) R at MMC at seating plane.

MECHANICAL

U Package (DAC703 Only)

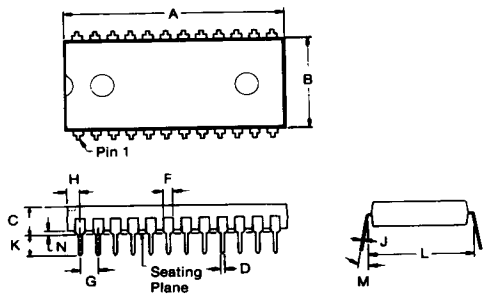


DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	.602	.618	15.29	15.70
A_1	.595	.618	15.11	15.70
B	.286	.302	7.26	7.67
B_1	.270	.285	6.86	7.24
C	.093	.108	2.36	2.74
D	.015	.019	0.38	0.48
G	.050 BASIC		1.27 BASIC	
H	.026	.034	0.66	0.86
J	.008	.012	0.20	0.30
L	.390	.422	9.91	10.72
M	0°	10°	0°	10°
N	.000	.012	0.00	0.30

NOTE: Leads in true position within 0.01" (0.25mm) R at MMC at seating plane.

MECHANICAL

P Package



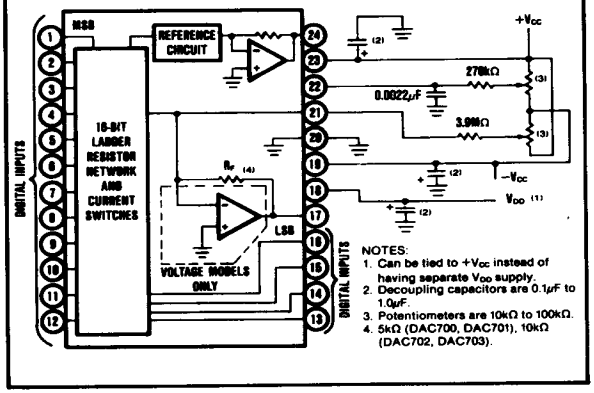
DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	1.233	1.263	31.32	32.59
B	.538	.575	13.67	14.61
C	.169	.224	4.29	5.70
D	.015	.023	0.38	0.58
F	.043	.062	1.09	1.57
G	.100 BASIC		2.54 BASIC	
H	.030	.090	0.76	2.29
J	.008	.015	0.20	0.38
K	.100	.132	2.54	3.35
L	.600 BASIC		15.24 BASIC	
M	0°	15°	0°	15°
N	.018	.022	0.46	0.56

NOTE: Leads in true position within .010" (.25mm) R at MMC at seating plane.

PIN ASSIGNMENTS

Pin #	H and P Packages	
	DAC700/702	DAC701/703
1	Bit 1 (MSB)	Bit 1 (MSB)
2	Bit 2	Bit 2
3	Bit 3	Bit 3
4	Bit 4	Bit 4
5	Bit 5	Bit 5
6	Bit 6	Bit 6
7	Bit 7	Bit 7
8	Bit 8	Bit 8
9	Bit 9	Bit 9
10	Bit 10	Bit 12
11	Bit 11	Bit 11
12	Bit 12	Bit 12
13	Bit 13	Bit 13
14	Bit 14	Bit 14
15	Bit 15	Bit 15
16	Bit 16 (LSB)	Bit 16 (LSB)
17	$R_{FEEDBACK}$	V_{OUT}
18	V_{DD}	V_{DD}
19	$-V_{CC}$	$-V_{CC}$
20	Common	Common
21	I_{OUT}	Summing Junction (Zero Adjust)
22	Gain Adjust	Gain Adjust
23	$+V_{CC}$	$+V_{CC}$
24	+6.3V Reference Output	+6.3V Reference Output

CONNECTION DIAGRAMS



ORDERING INFORMATION

Model	Package	Output Configuration	Temperature Range	Linearity Error, max at 25°C (% of FSR)	Gain Drift max, (ppm/°C)
DAC702JP, DAC703JP	Plastic DIP	±1mA, ±10V	0°C to +70°C	±0.006	±30
DAC702KP, DAC703KP	Plastic DIP	±1mA, ±10V	0°C to +70°C	±0.003	±25
DAC700KH, DAC701KH	Ceramic DIP	0 to −1mA, 0 to +10V	0°C to +70°C	±0.003	±25
DAC702KH, DAC703KH	Ceramic DIP	±1mA, ±10V	0°C to +70°C	±0.003	±25
DAC700BH, DAC701BH	Ceramic DIP	0 to −1mA, 0 to +10V	−25°C to +85°C	±0.003	±15
DAC702BH, DAC703BH	Ceramic DIP	±1mA, ±10V	−25°C to +85°C	±0.003	±15
DAC700BH/QM, DAC701BH/QM	Ceramic DIP	0 to −1mA, 0 to +10V	−25°C to +85°C	±0.003	±15
DAC702BH/QM, DAC703BH/QM	Ceramic DIP	±1mA, ±10V	/QM screening	±0.003	±15
DAC700LH, DAC701LH	Ceramic DIP	0 to −2mA, 0 to +10V	0°C to +70°C	±0.0015	±10
DAC700CH, DAC701CH	Ceramic DIP	0 to −2mA, 0 to +10V	−25°C to +85°C	±0.0015	±10
DAC700SH, DAC701SH	Ceramic DIP	0 to −1mA, 0 to +10V	−55°C to +125°C	±0.003	±15
DAC702LH, DAC703LH	Ceramic DIP	±1mA, ±10V	0°C to +70°C	±0.0015	±10
DAC702CH, DAC703CH	Ceramic DIP	±1mA, ±10V	−25°C to +85°C	±0.0015	±10
DAC702SH, DAC703SH	Ceramic DIP	±1mA, ±10V	−55°C to +125°C	±0.003	±15
DAC700SH/QM, DAC701SH/QM	Ceramic DIP	0 to −1mA, 0 to +10V	−55°C to +125°C	±0.003	±15
DAC702SH/QM, DAC703SH/QM	Ceramic DIP	±1mA, ±10V	/QM screening	±0.003	±15

BURN-IN SCREENING OPTION
See text for details.

Model	Package	Output Configuration	Temperature Range	Linearity Error, max at 25°C (% of FSR)	Burn-In Temp. (160h)[1]
DAC702JP-BI	Plastic DIP	±1mA	0°C to +70°C	±0.006	85°C
DAC703JP-BI	Plastic DIP	±10V	0°C to +70°C	±0.006	85°C
DAC702KP-BI	Plastic DIP	±1mA	0°C to +70°C	±0.003	85°C
DAC703KP-BI	Plastic DIP	±10V	0°C to +70°C	±0.003	85°C
DAC703JU	Plastic SOIC	±10V	0°C to +70°C	±0.006	85°C
DAC703KU	Plastic SOIC	±10V	0°C to +70°C	±0.003	85°C
DAC703JU-BI	Plastic SOIC	±10V	0°C to +70°C	±0.006	85°C
DAC703KU-BI	Plastic SOIC	±10V	0°C to +70°C	±0.003	85°C
DAC700KH-BI	Ceramic DIP	0 to −1mA	0°C to +70°C	±0.003	85°C
DAC700LH-BI	Ceramic DIP	0 to −2mA	0°C to +70°C	±0.0015	85°C
DAC700BH-BI	Ceramic DIP	0 to −1mA	−25°C to +85°C	±0.003	85°C
DAC700CH-BI	Ceramic DIP	0 to −2mA	−25°C to +85°C	±0.0015	85°C
DAC700SH-BI	Ceramic DIP	0 to −1mA	−55°C to +125°C	±0.003	125°C
DAC701KH-BI	Ceramic DIP	0 to +10V	0°C to +70°C	±0.003	85°C
DAC701LH-BI	Ceramic DIP	0 to +10V	0°C to +70°C	±0.0015	85°C
DAC701BH-BI	Ceramic DIP	0 to +10V	−25°C to +85°C	±0.003	85°C
DAC701CH-BI	Ceramic DIP	0 to +10V	−25°C to +85°C	±0.0015	85°C
DAC701SH-BI	Ceramic DIP	0 to +10V	−55°C to +125°C	±0.003	125°C
DAC702KH-BI	Ceramic DIP	±1mA	0°C to +70°C	±0.003	85°C
DAC702LH-BI	Ceramic DIP	±1mA	0°C to +70°C	±0.0015	85°C
DAC702BH-BI	Ceramic DIP	±1mA	−25°C to +85°C	±0.003	85°C
DAC702CH-BI	Ceramic DIP	±1mA	−25°C to +85°C	±0.0015	85°C
DAC702SH-BI	Ceramic DIP	±1mA	−55°C to +125°C	±0.003	125°C
DAC703KH-BI	Ceramic DIP	±10V	0°C to +70°C	±0.003	85°C
DAC703LH-BI	Ceramic DIP	±10V	0°C to +70°C	±0.0015	85°C
DAC703BH-BI	Ceramic DIP	±10V	−25°C to +85°C	±0.003	85°C
DAC703CH-BI	Ceramic DIP	±10V	−25°C to +85°C	±0.0015	85°C
DAC703SH-BI	Ceramic DIP	±10V	−55°C to +125°C	±0.003	125°C

NOTE: (1) Or equivalent combination of time and temperature.

ABSOLUTE MAXIMUM RATINGS

+V_{CC} to Common ..... 0V, +18V
−V_{CC} to Common ..... 0V, −18V
V_{DD} to Common ..... 0V, +18V
Digital Data Inputs to Common ..... −1V, +18V
Reference Out to Common ..... Indefinite Short to Common
External Voltage Applied to R_F (DAC700/702) ..... ±18V
External Voltage Applied to D/A Output (DAC701/703) ..... −5V to +5V
V_{OUT} (DAC701/703) ..... Indefinite Short to Common
Power Dissipation 1000mW
Storage Temperature ..... −60°C to +150°C
Lead Temperature (soldering, 10s) ..... 300°C

*Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. Exposure to absolute maximum conditions for extended periods may affect device reliability.

DISCUSSION OF SPECIFICATIONS

DIGITAL INPUT CODES

The DAC700/701/702/703 accept complementary digital input codes in either binary format (CSB, Unipolar or COB, Bipolar). The COB models DAC702/703 may be connected by the user for either complementary offset binary (COB) or complementary two's complement (CTC) codes (see Table I).

TABLE I. Digital Input Codes.

Digital Input Codes	Analog Output		
	DAC700/701 Complementary Straight Binary (CSB)	DAC702/703 Complementary Offset Binary (COB)	DAC702/703 Complementary Two's Complement (CTC)*
0000_H	+ Full Scale	+ Full Scale	−1LSB
$7FFF_H$	+1/2 Full Scale	Bipolar Zero	− Full Scale
8000_H	+1/2 Full Scale −1LSB	−1LSB	+ Full Scale
$FFFF_H$	Zero	− Full Scale	Bipolar Zero

*Invert the MSB of the COB code with an external inverter to obtain CTC code.

ACCURACY

Linearity

This specification describes one of the most important measures of performance of a D/A converter. Linearity error is the deviation of the analog output from a straight line drawn through the end points (all bits ON point and all bits OFF point).

Differential Linearity Error

Differential Linearity Error (DLE) of a D/A converter is the deviation from an ideal 1LSB change in the output from one adjacent output state to the next. A differential linearity error specification of ±1/2LSB means that the output step sizes can be between 1/2LSB and 3/2LSB when the input changes from one adjacent input state to the next. A negative DLE specification of no more than −1LSB (−0.006% for 14-bit resolution) insures monotonicity.

Monotonicity

Monotonicity assures that the analog output will increase or remain the same for increasing input digital codes. The DAC700/701/702/703 are specified to be monotonic to 14 bits over the entire specification temperature range.

DRIFT

Gain Drift

Gain drift is a measure of the change in the full-scale range output over temperature expressed in parts per million per degree centigrade (ppm/°C). Gain drift is established by: (1) testing the end point differences for each D/A at t_{min}, +25°C and t_{max}; (2) calculating the gain error with respect to the +25°C value; and (3) dividing by the temperature change.

Zero Drift

Zero drift is a measure of the change in the output with $FFFF_H$ (DAC700 and DAC701) applied to the digital inputs over the specified temperature range. For the bipolar models, zero is measured at $7FFF_H$ (bipolar zero) applied to the digital inputs. This code corresponds to zero volts (DAC703) or zero milliamps (DAC702) at the analog output. The maximum change in offset at t_{min} or t_{max} is referenced to the zero error at +25°C and is divided by the temperature change. This drift is expressed in parts per million of full scale range per degree centigrade (ppm of FSR/°C).

SETTLING TIME

Settling time of the D/A is the total time required for the analog output to settle within an error band around its final value after a change in digital input. Refer to Figure 1 for typical values for this family of products.

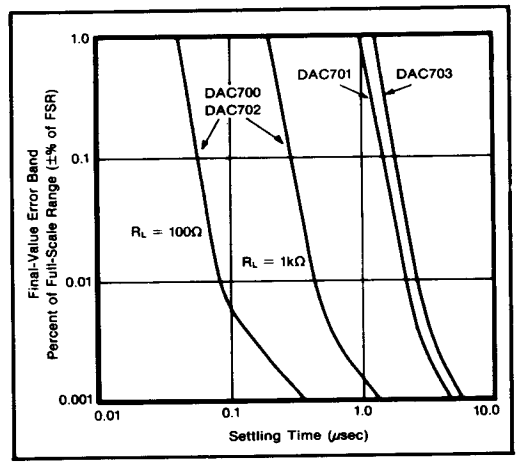


FIGURE 1. Final-Value Error Band Versus Full-Scale Range Settling Time.

Voltage Output

Settling times are specified to ±0.003% of FSR (±1/2 LSB for 14 bits) for two input conditions: a full-scale range change of 20V (DAC703) or 10V (DAC701) and a 1LSB change at the "major carry," the point at which the worst-case settling time occurs. (This is the worst-case point since all of the input bits change when going from one code to the next).

Current Output

Settling times are specified to±0.003% of FSR for a full-scale range change for two output load conditions: one for 10Ω to 100Ω and one for 1000Ω. It is specified this way because the output RC time constant becomes the dominant factor in determining settling time for large resistive loads.

COMPLIANCE VOLTAGE

Compliance voltage applies only to current output models. It is the maximum voltage swing allowed on the output current pin while still being able to maintain specified accuracy.

POWER SUPPLY SENSITIVITY

Power supply sensitivity is a measure of the effect of a change in a power supply voltage on the D/A converter output. It is defined as a percent of FSR change in the output per percent of change in either the positive supply ($+V_{CC}$), negative supply ($-V_{CC}$) or logic supply (V_{DD}) about the nominal power supply voltages (see Figure 2).

It is specified for DC or low frequency changes. The typical performance curve in Figure 2 shows the effect of high frequency changes in power supply voltages.

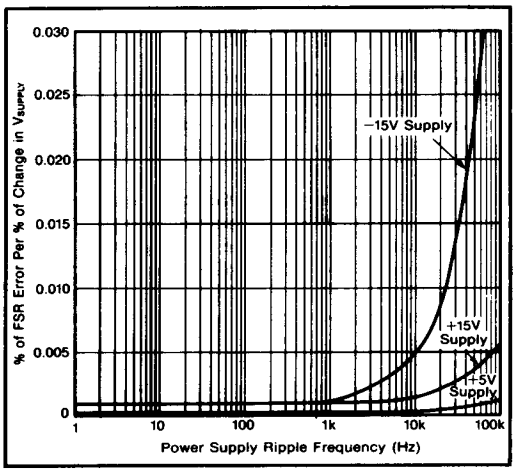


FIGURE 2. Power Supply Rejection Versus Power Supply Ripple Frequency.

REFERENCE SUPPLY

All models have an internal low-noise +6.3V reference voltage derived from an on-chip buried zener diode. This reference voltage, available to the user, has a tolerance of ±5% (KH models) and ±1% (BH models). A minimum of 1.5mA is available for external loads. Since the output impedance of the reference output is typically 1Ω, the external load should remain constant.

If a varying load is to be driven by the reference supply, an external buffer amplifier is recommended to drive the load in order to isolate the Bipolar Offset (connected internally to the reference) from load variations.

BURN-IN SCREENING

Burn-in screening is an option available for the entire DAC700 through DAC703 family of products. Burn-in duration is 160 hours at the temperature shown below (or equivalent combination of time and temperature).

Model	Temp. Range	Burn-In Screening
DAC703KU-BI	0°C to +70°C	160 hours at 85°C
DAC700BH-BI	−25°C to +85°C	160 hours at 85°C
DAC702SH-BI	−55°C to +125°C	160 hours at 125°C

All units are tested after burn-in to ensure that grade specifications are met. To order burn-in, add "-BI" to the base model number.

ENVIRONMENTAL SCREENING /QM Screening

Screening Flow For /QM Models

Screen	MIL-STD-883 Method	Condition	Comments
Internal Visual	2010	B	
High Temperature Storage (Stabilization Bake)	1008	C	+150°C, 24hrs
Temperature Cycling	1010	C	−65 to +150°C, 10 cycles
Burn-in	1015	B	+125°C, 160hrs
Constant Acceleration	2001	E	30,000 Gs
Hermeticity Fine Leak Gross Leak	 1014 1014	 A1 or A2 C	 5×10^{-8} atm cc/sec 60psig, 2hrs
External Visual	2009		

Burr-Brown /QM models are environmentally-screened versions of our standard industrial products, designed to provide enhanced reliability. The screening, tabulated below, is performed to selected methods of MIL-STD-883. Reference to these methods provides a convenient method of communicating the screening levels and basic procedures employed; it does not imply conformance to any other military standards or to any methods of MIL-STD-883 other than those specified below. Burr-Brown's detailed procedures may vary slightly, model-to-model, from those in MIL-STD-883.

OPERATING INSTRUCTIONS

POWER SUPPLY CONNECTIONS

For optimum performance and noise rejection, power supply decoupling capacitors should be added as shown in the Connection Diagram. 1μF tantalum capacitors should be located close to the D/A converter.

EXTERNAL ZERO AND GAIN ADJUSTMENT

Zero and gain may be trimmed by installing external zero and gain potentiometers. Connect these potentiometers as shown in the Connection Diagram and adjust as described below. TCR of the potentiometers should

be 100ppm/°C or less. The 3.9MΩ and 270kΩ resistors (±20% carbon or better) should be located close to the D/A converter to prevent noise pickup. If it is not convenient to use these high-value resistors, an equivalent "T" network, as shown in Figure 3, may be substituted in place of the 3.9MΩ part. A 0.001μF to 0.01μF ceramic capacitor should be connected from Gain Adjust to Common to prevent noise pickup. Refer to Figures 4 and 5 for the relationship of zero and gain adjustments to unipolar and bipolar D/A converters.

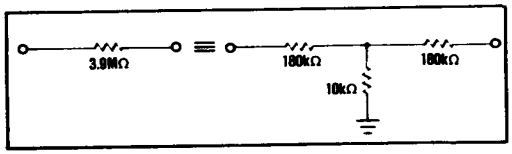


FIGURE 3. Equivalent Resistances.

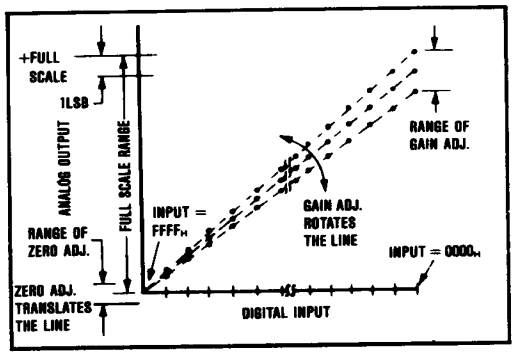


FIGURE 4. Relationship of Zero and Gain Adjustments for Unipolar D/A Converters, DAC700 and DAC701.

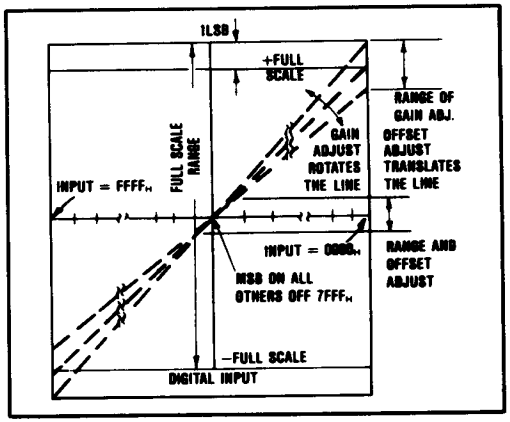


FIGURE 5. Relationship of Zero and Gain Adjustments for Bipolar D/A converters, DAC702 and DAC703.

Zero Adjustment

For unipolar (CSB) configurations, apply the digital input code that produces zero voltage or zero current output and adjust the zero potentiometer for zero output.

For bipolar (COB, CTC) configurations, apply the digital input code that produces zero output voltage or current. See Table II for corresponding codes and the Connection Diagram for zero adjustment circuit connections. Zero calibration should be made before gain calibration.

Gain Adjustment

Apply the digital input that gives the maximum positive output voltage. Adjust the gain potentiometer for this positive full scale voltage. See Table II for positive full scale voltages and the Connection Diagram for gain adjustment circuit connections.

INSTALLATION CONSIDERATIONS

This D/A converter family is laser-trimmed to 14-bit linearity. The design of the device makes the 16-bit resolution available. If 16-bit resolution is not required, bit 15 and bit 16 should be connected to V_{DD} through a single 1kΩ resistor.

Due to the extremely-high resolution and linearity of the D/A converter, system design problems such as grounding and contact resistance become very important. For a 16-bit converter with a +10V full-scale range, 1LSB is 153μV. With a load current of 5mA, series wiring and connector resistance of only 30mΩ will cause the output to be in error by 1LSB. To understand what this means in terms of a system layout, the resistance of #23 wire is about 0.021Ω/ft. Neglecting contact resistance, less than 18 inches of wire will produce a 1LSB error in the analog output voltage!

In Figures 6, 7, and 8, lead and contact resistances are represented by R_1 through R_5. As long as the load resistance R_L is constant, R_2 simply introduces a gain error and can be removed during initial calibration. R_3 is part of R_L, if the output voltage is sensed at Common, and therefore introduces no error. If R_L is variable, then R_2 should be less than $R_{Lmin}/2^{16}$ to reduce voltage drops due to wiring to less than 1LSB. For example, if R_{Lmin} is 5kΩ, then R_2 should be less than 0.08Ω. R_L should be located as close as possible to the D/A converter for optimum performance. The effect of R_4 is negligible.

In many applications it is impractical to sense the output voltage at the output pin. Sensing the output voltage at the system ground point is permissible with the DAC700 family because the D/A converter is designed to have a constant return current of approximately 2mA flowing from Common. The variation in this current is under 20μA (with changing input codes), therefore R_4 can be as large as 3Ω without adversely affecting the linearity of the D/A converter. The voltage drop across R_4 ($R_4 \times$ 2mA) appears as a zero error and can be removed with

TABLE II. Digital Input and Analog Output Relationships.

VOLTAGE OUTPUT MODELS						
	Analog Output					
	DAC701 Unipolar			DAC703 Bipolar		
Digital Input Code	16-bit	15-bit	14-bit	16-bit	15-bit	14-bit
One LSB (μV)	153	305	610	305	610	1224
0000_H (V)	+9.99985	+9.99969	+9.99939	+9.99960	+9.99939	+9.99878
$FFFF_H$ (V)	0	0	0	−10.0000	−10.0000	−10.0000
CURRENT OUTPUT MODELS						
	Analog Output					
	DAC700 Unipolar			DAC702 Bipolar		
Digital Input Code	16-bit	15-bit	14-bit	16-bit	15-bit	14-bit
One LSB (μA)	0.031	0.061	0.122	0.031	0.061	0.122
0000_H (mA)	−1.99997	−1.99994	−1.99988	−0.99997	−0.99994	−0.99988
$FFFF_H$ (mA)	0	0	0	+1.00000	+1.00000	+1.00000

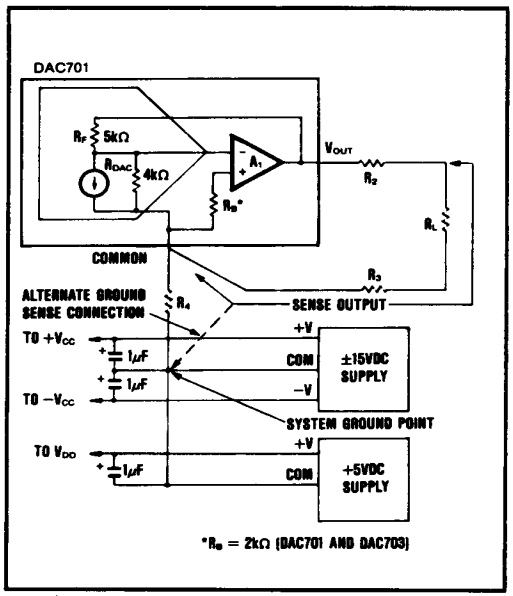


FIGURE 6. Output Circuit for Voltage Models.

the zero calibration adjustment. This alternate sensing point (the system ground point) is shown in Figures 6, 7, and 8.

Figures 7 and 8 show two methods of connecting the current output models (DAC700 or DAC702) with external precision output op amps. By sensing the output voltage at the load resistor (i.e., by connecting R_F to the output of A_1 at R_L), the effect of R_1 and R_2 is greatly reduced. R_1 will cause a gain error but is independent of the value of R_L and can be eliminated by initial calibration adjustments. The effect of R_2 is negligible because it is inside the feedback loop of the output op amp and is therefore greatly reduced by the loop gain.

If the output cannot be sensed at Common or the system ground point as mentioned above, the differential output circuit shown in Figure 8 is recommended. In this circuit the output voltage is sensed at the load common and not at the D/A converter common as in the previous circuits. The value of R_6 and R_7 must be adjusted for maximum common-mode rejection at R_L. Note that if R_3 is negligible, the circuit of Figure 8 can be reduced to the one shown in Figure 7. Again the effect of R_4 is negligible.

The D/A converter and the wiring to its connectors should be located to provide optimum isolation from sources of RFI and EMI. The key concept in elimination of RF radiation or pickup is loop area; therefore, signal leads and their return conductors should be kept close

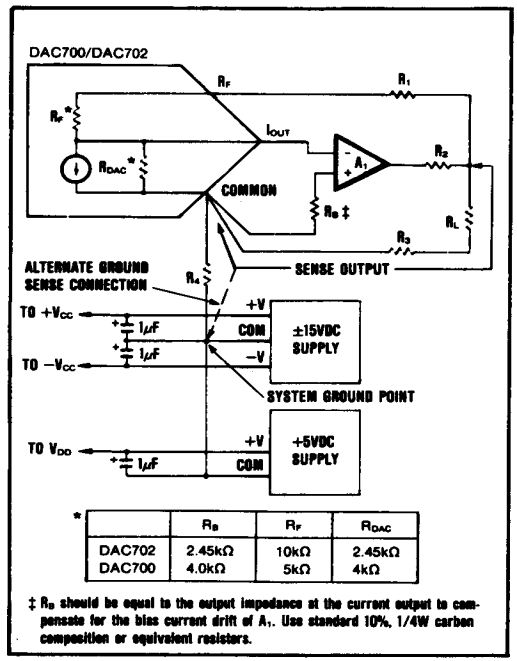


FIGURE 7. Preferred External Op Amp Configuration.

together. This reduces the external magnetic field along with any radiation. Also, if a single lead and its return conductor are wired close together, they present a small flux-capture cross section for any external field. This reduces radiation pickup in the circuit.

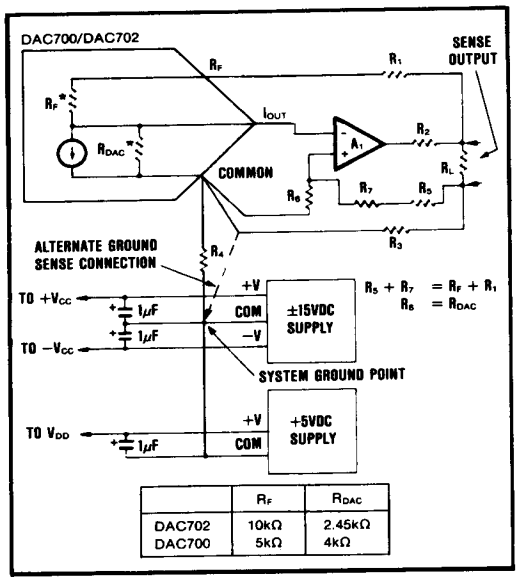


FIGURE 8. Differential Sensing Output Op Amp Configuration.

APPLICATIONS

DRIVING AN EXTERNAL OP AMP WITH CURRENT OUTPUT D/As

DAC700 and DAC702 are current output devices and will drive the summing junction of an op amp to produce an output voltage as shown in Figure 9. Use of the internal feedback resistor is required to obtain specified gain accuracy and low gain drift.

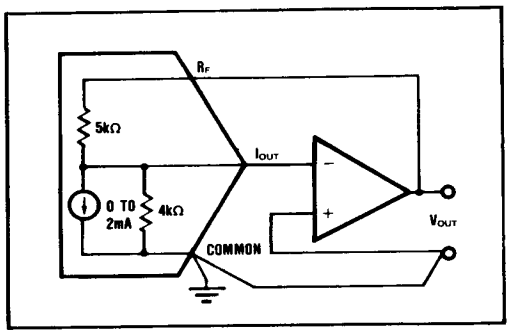


FIGURE 9. External Op Amp Using Internal Feedback Resistors.

DAC700 or DAC702 can be scaled for any desired voltage range with an external feedback resistor, but at the expense of increased drifts of up to ±50ppm/°C. The resistors in the DAC700 and DAC702 ratio track to ±1ppm/°C but their absolute TCR may be as high as ±50ppm/°C.

An alternative method of scaling the output voltage of the D/A converter and preserving the low gain drift is shown in Figure 10.

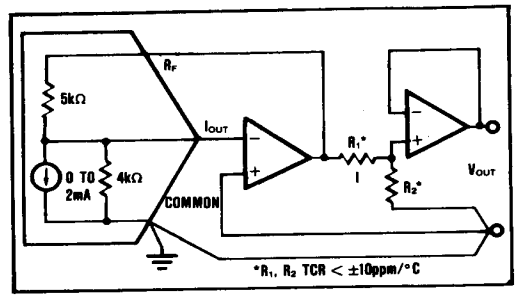


FIGURE 10. External Op Amp Using Internal and External Feedback Resistors to Maintain Low Gain Drift.

OUTPUTS LARGER THAN 20-VOLT RANGE

For output voltage ranges larger than ±10V, a high voltage op amp may be employed with an external feedback resistor. Use I_{OUT} values of ±1mA for bipolar voltage ranges and −2mA for unipolar voltage ranges (see Figure 11). Use protection diodes as shown when a high voltage op amp is used.

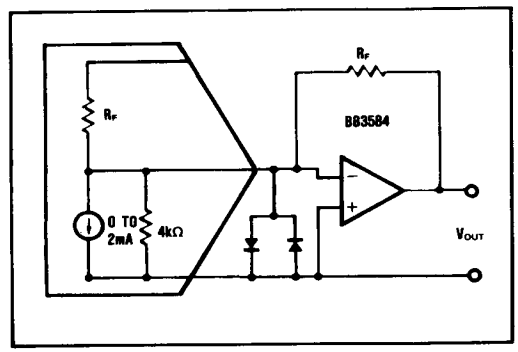


FIGURE 11. External Op Amp Using External Feedback Resistors.