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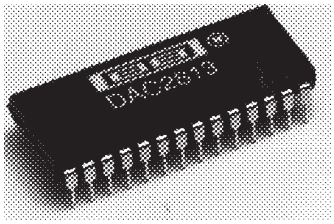


DAC2813

DUAL 12-BIT DIGITAL-TO-ANALOG CONVERTER (12-bit port interface)

FEATURES

- COMPLETE WITH REFERENCE AND OUTPUT AMPLIFIERS
- 12-BIT PORT INTERFACE
- ANALOG OUTPUT RANGE: ±10V
- MONOTONICITY GUARANTEED OVER TEMPERATURE
- INTEGRAL LINEARITY ERROR: ±1/2LSB max
- ±12V to ±15V SUPPLIES
- 28-PIN PLASTIC DIP PACKAGE

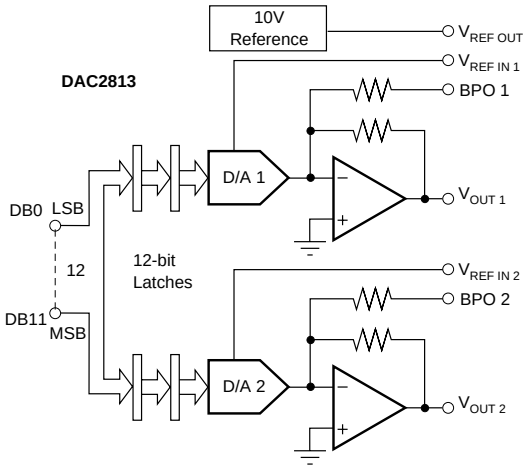
DESCRIPTION

DAC2813 is a complete dual 12-bit digital-to-analog converter with bus interface logic. Each package includes a precision +10V voltage reference, double-buffered bus interface including a RESET function and 12-bit D/A converters with voltage-output operational amplifiers.

The double-buffered interface consists of a 12-bit input latch and a D/A latch for each D/A converter. A RESET control allows the D/A outputs to be asynchronously reset to bipolar zero, a feature useful for power-up reset, system initialization and recalibration.

DAC2813 output range resistors are internally connected for 20V full scale range. A 0 to 10V range can be connected using the bipolar offset resistor. Gain and bipolar offset of each D/A are adjustable with external trim potentiometers.

DAC2813 is available in one performance grade with a integral linearity error of 1/2LSB and 12-bit monotonicity guaranteed over temperature. It is packaged in 28-pin 0.6in. wide plastic DIP package and specified over –40°C to +85°C.



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SPECIFICATIONS

ELECTRICAL

At T_A = +25°C, $+V_{CC}$ = +12V or +15V, $-V_{CC}$ = –12V or –15V, unless otherwise noted.

PARAMETER	CONDITIONS	DAC2813AP MIN	DAC2813AP TYP	DAC2813AP MAX	UNITS
INPUTS					
DIGITAL INPUTS	Over Temperature				
Input Code [1]	Range		Bipolar Offset Binary		
Logic Levels [2]					
V_{IH}		+2		+5.5[3]	V
V_{IL}		0		+0.8	V
Logic Input Currents					
DB0-DB11, $\overline{WR}$, $\overline{LDAC}$, $\overline{RESET}$,$\overline{EN}_X$					
I_{IH}	V_I = +2.7V			±20	µA
I_{IL}	V_I = +0.4V			±20	µA
TRANSFER CHARACTERISTICS					
ACCURACY					
Linearity Error			±1/4	±1/2	LSB
Differential Linearity Error			±1/2	±1	LSB
Gain Error [5,6]			±0.05	±0.2	%
Bipolar Zero Error [5,7]			±0.05	±0.2	%FSR[4]
Power Supply Sensitivity					
Of Full Scale $+V_{CC}$			±5	±20	ppmFSR/%$+V_{CC}$
$-V_{CC}$			±1	±10	ppmFSR/%$-V_{CC}$
DRIFT	Over Specification Temperature Range				
Gain			±5	±30	ppm/°C
Bipolar Zero Drift			±5	±15	ppmFSR/°C
Linearity Error over Temperature			±1/2	±3/4	LSB
Monotonicity			Guaranteed		
DYNAMIC CHARACTERISTICS					
SETTLING TIME [8]	To within ±0.012%FSR of Final Value 5kΩ || 500pF Load				
Full Scale Range Change	20V Range		4.5	6	µs
1LSB Output Step [9] At Major Carry			2		µs
Slew Rate			10		V/µs
Crosstalk [10]	5kΩ Loads		0.1		LSB
OUTPUT					
Output Voltage Range	$\pm V_{CC} \geq \pm 11.4V$			±10	V
Output Current		±5			mA
Output Impedance			0.2		Ω
Short Circuit to ACOM Duration			Indefinite		
REFERENCE VOLTAGE					
Voltage		+9.95	+10.00	+10.05	V
Source Current Available for External Loads		2			mA
Impedance			0.2		Ω
Temperature Coefficient			±5	±25	ppm/°C
Short Circuit to Common Duration			Indefinite		
POWER SUPPLY REQUIREMENTS					
Voltage:$+V_{CC}$		+11.4	+15	+16.5	V
$-V_{CC}$		–11.4	–15	–16.5	V
Current:	No Load $\pm V_{CC}$ = ±15V				
$+V_{CC}$			24	30	mA
$-V_{CC}$			12	14	mA
Power Dissipation			540	660	mW
Potential at DCOM with Respect to ACOM [11]		–3		+3	V
TEMPERATURE RANGES					
Specification		–40		+85	°C
Storage		–60		+100	°C
Thermal Resistance, θ_{JA},Plastic DIP			30		°C/W

NOTES: (1) For Two's Complement Input Coding invert the MSB with an external logic inverter. (2) Digital inputs are TTL and +5V CMOS compatible over the specification temperature range. (3) Open DATA input lines will be pulled above +5.5V. See discussion under LOGIC INPUT COMPATIBILITY section. (4) FSR means Full Scale Range. For example, for ±10V output, FSR = 20V. (5) Adjustable to zero with external trim potentiometer. (6) Specified with 500Ω connected between $V_{REF\,OUT}$ and $V_{REF\,IN}$. (7) Error at input code 800_{HEX}. DAC2813 specified with 100Ω connected between$V_{REF\,OUT}$ and $V_{REF\,IN}$; and with 500Ω connected between $V_{REF\,OUT}$ and BPO. (8) Maximum represents the 3σ limit. Not 100% tested for this parameter. (9) For the worst-case code change: $7FF_{HEX}$ to 800_{HEX} and 800_{HEX} to $7FF_{HEX}$. (10) Crosstalk is defined as the change in any output as a result of any other output being driven from –10V to +10V at rated output current. (11) The maximum voltage at which ACOM and DCOM may be separated without affecting accuracy specifications.

ABSOLUTE MAXIMUM RATINGS(1)

$+V_{CC}$ to ACOM	0 to +18V
$-V_{CC}$ to ACOM	0 to –18V
$+V_{CC}$ to $-V_{CC}$	0 to +36V
ACOM to DCOM	±4V
Digital Inputs to DCOM	–1V to $+V_{CC}$
External Voltage applied to BPO Resistor	±18V
$V_{REF\ OUT}$	Indefinite short to ACOM
V_{OUT}	Momentary to ±18V
Lead Temperature, soldering 10s	+300°C
Max Junction Temperature	165°C

NOTE: (1) 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.

ELECTROSTATIC DISCHARGE SENSITIVITY

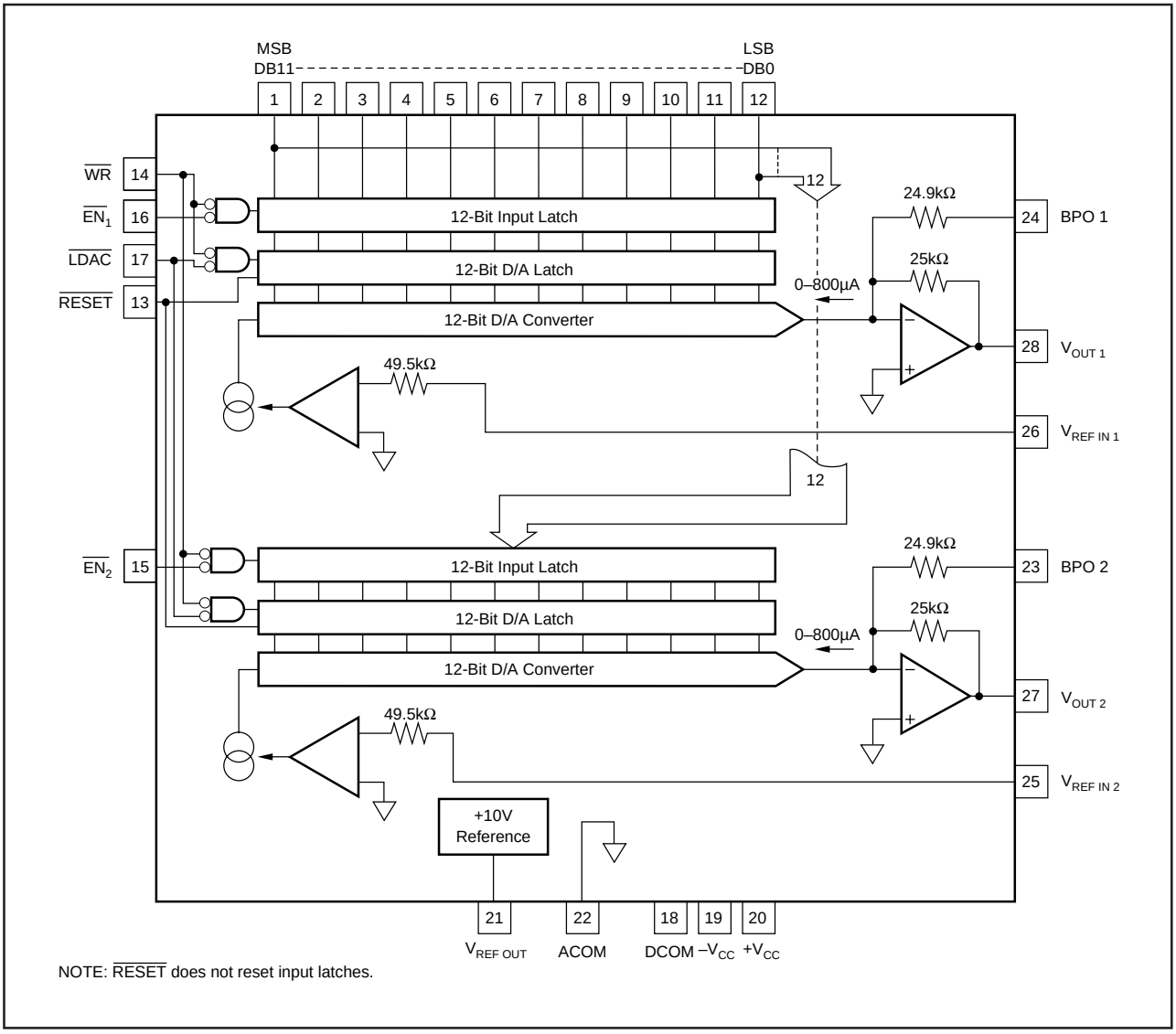
Electrostatic discharge can cause damage ranging from performance degradation to complete device failure. Burr-Brown Corporation recommends that all integrated circuits be handled and stored using appropriate ESD protection methods.

PACKAGE/ORDERING INFORMATION

PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER(1)	TEMPERATURE RANGE
DAC2813AP	28-Pin DBL Wide DIP	215	–40°C to +85°C

NOTE: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix C of Burr-Brown IC Data Book.

BLOCK DIAGRAM

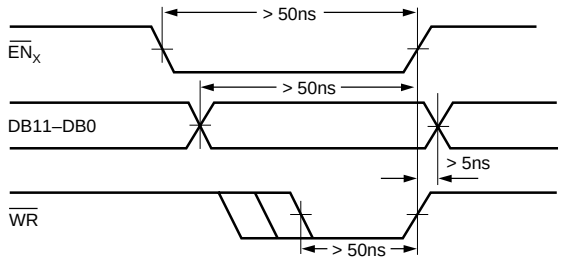


NOTE: $\overline{RESET}$ does not reset input latches.

TIMING DIAGRAMS

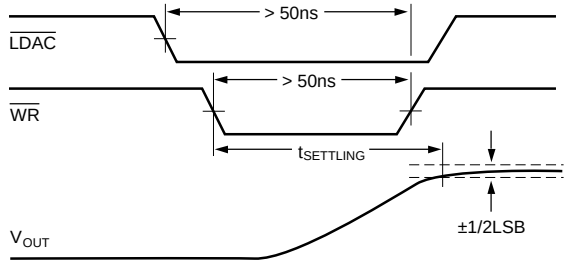
WRITE CYCLE #1

(Load first rank from Data Bus: $\overline{LDAC}$ = 1)



WRITE CYCLE #2

(Load second rank from first rank: $\overline{EN}_X$ = 1)



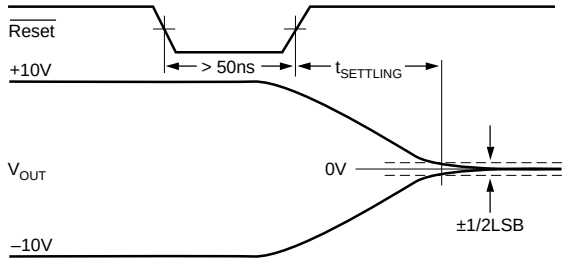
TRUTH TABLE

$\overline{WR}$	$\overline{EN1}$	$\overline{EN2}$	$\overline{LDAC}$	$\overline{RESET}$	OPERATION
X	X	X	X	0	Reset both D/A Latches. Does not reset input latches.
1	X	X	X	1	No Operation
X	1	1	1	1	No Operation
0	1	0	1	1	Load Data into First Rank for D/A 2
0	0	1	1	1	Load Data into First Rank for D/A 1
0	1	1	0	1	Load Second Rank from First Rank, both D/As
0	0	0	0	1	All Latches Transparent

"X" = Don't Care

RESET COMMAND (Bipolar Mode)

$\overline{EN}_X$, $\overline{LDAC}$, $\overline{WR}$ = Don't Care



PIN DESCRIPTIONS

PIN	NAME	FUNCTION
1	DB11	DATA, MSB, positive true.
2	DB10	DATA
3	DB9	DATA
4	DB8	DATA
5	DB7	DATA
6	DB6	DATA
7	DB5	DATA
8	DB4	DATA
9	DB3	DATA
10	DB2	DATA
11	DB1	DATA
12	DB0	DATA, LSB.
13	$\overline{RESET}$	Resets output of all D/As to bipolar-zero. The D/A remains in this state until overwritten an $\overline{LDAC}$-$\overline{WR}$ command. RESET does not reset the input latch. After power–up and reset, input latches will be in an indeterminant state.
14	$\overline{WR}$	Write strobe. Must be low for data transfer to any latch (except RESET).
15	$\overline{EN2}$	Enable for 12-bit input data latch of D/A 2. NOTE: This logic path is slower than the WR\ path.
16	$\overline{EN1}$	Enable for 12-bit input data latch of D/A 1. NOTE: This logic path is slower than the WR\ path.
17	$\overline{LDAC}$	Load DAC enable. Must be low with $\overline{WR}$ for data transfer to the D/A latch and simultaneous update of both D/A converters.
18	DCOM	Digital common, logic currents return.
19	$-V_{CC}$	Analog supply input, nominally –12V or –15V referred to ACOM.
20	$+V_{CC}$	Analog supply input, nominally +12V or +15V referred to ACOM.
21	$V_{REF\ OUT}$	+10V reference output.
22	ACOM	Analog common, $+V_{CC}$, $-V_{CC}$ supply return.
23	BPO2	Bipolar offset. Connect to pin 21 ($V_{REF\ OUT}$) through a 100Ω resistor or through a 200 potentiometer for Bipolar Offset Adjust for D/A 2.
24	BPO1	Bipolar offset. Connect to pin 21 ($V_{REF\ OUT}$) through a 100Ω resistor or through a 200 potentiometer for Bipolar Offset Adjust or D/A 1.
25	$V_{REF\ IN\ 2}$	Connect to $V_{REF\ OUT}$ through 500Ω fixed resistor or through a 1kΩ gain adjustment potentiometer for D/A 2.
26	$V_{REF\ IN\ 1}$	Connect to $V_{REF\ OUT}$ through 500Ω fixed resistor or through a 1kΩ gain adjustment potentiometer for D/A 1.
27	$V_{OUT\ 2}$	D/A 2 analog output.
28	$V_{OUT\ 1}$	D/A 1 analog output.

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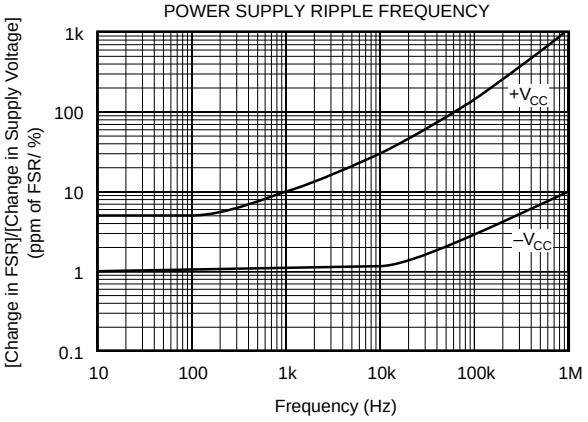
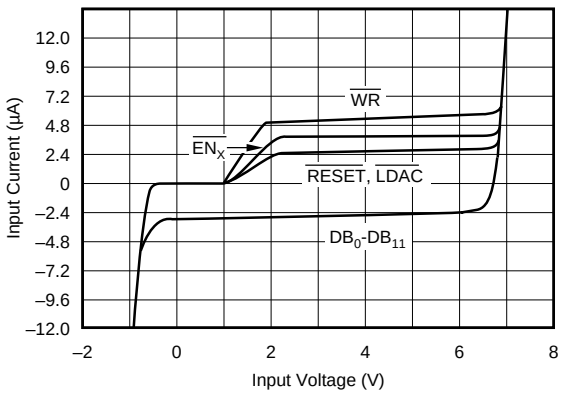
TYPICAL PERFORMANCE CURVES

At T_A = +25°C, V_{CC} = ±15V, unless otherwise noted.

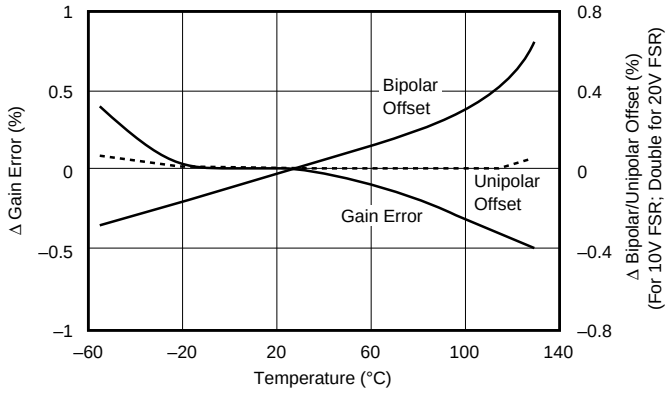
POWER SUPPLY REJECTION vs
POWER SUPPLY RIPPLE FREQUENCY



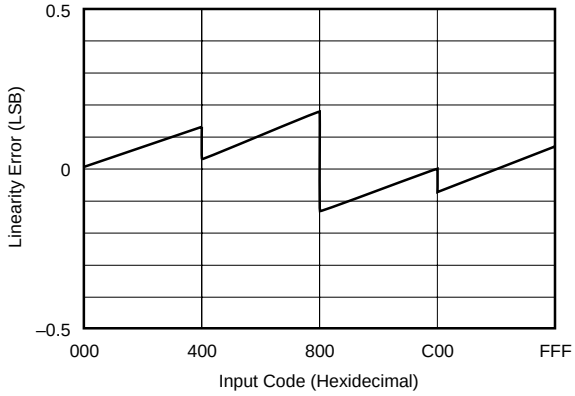
DIGITAL INPUT CURRENTvs INPUT VOLTAGE



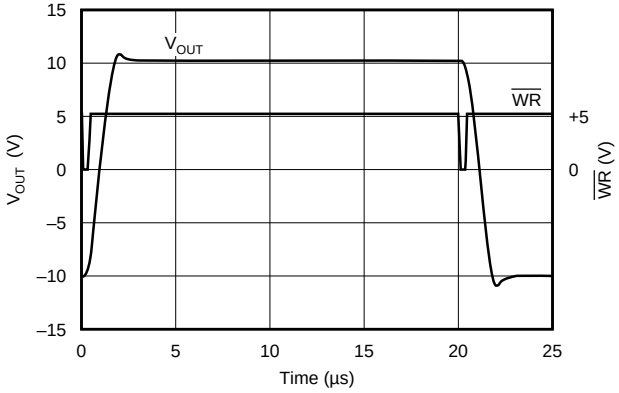
CHANGE OF GAIN AND OFFSET ERROR
vs TEMPERATURE



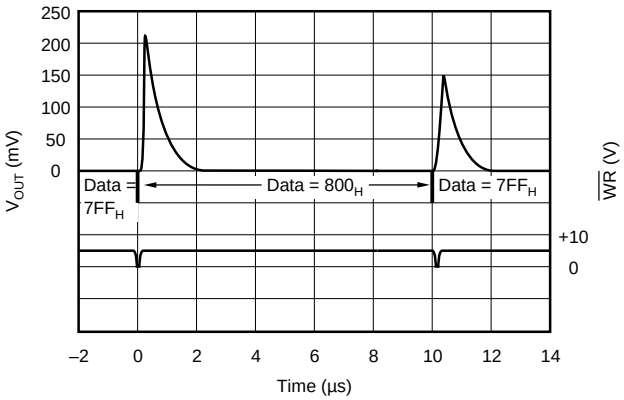
INTEGRAL LINEARITY ERROR



± FULL SCALE OUTPUT SWING

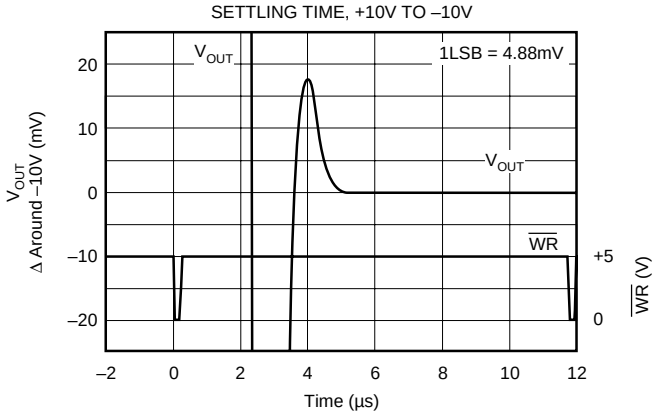


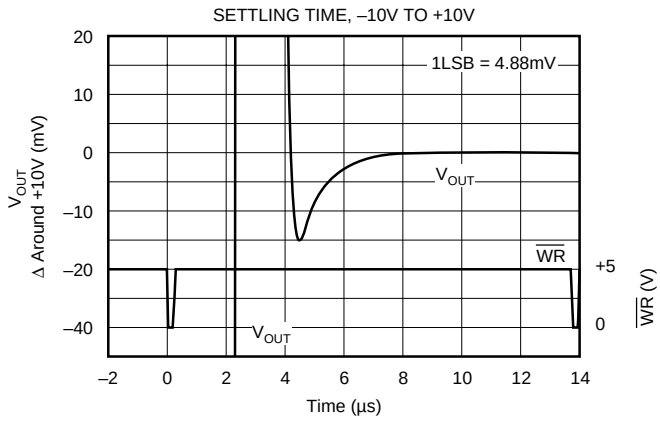
MAJOR CARRY GLITCH



TYPICAL PERFORMANCE CURVES (CONT)

At T_A = +25°C, V_{CC} = ±15V, unless otherwise noted.





DISCUSSION OF SPECIFICATIONS

LINEARITY ERROR

Linearity error is defined as the deviation of the analog output from a straight line drawn between the end points (digital inputs all "1s" and all "0s"). DAC2813 linearity error is ±1/2LSB max at +25°C.

DIFFERENTIAL LINEARITY ERROR

Differential Linearity Error (DLE) is the deviation from a 1LSB output change from one adjacent state to the next. A DLE specification of 1/2LSB means that the output step size can range from 1/2LSB to 3/2LSB when the digital input code changes from one code word to the adjacent code word If the DLE is more positive than –1LSB, the D/A is said to be monotonic.

MONOTONICITY

A D/A converter is monotonic if the output either increases or remains the same for increasing digital input values. DAC2813 is monotonic over their specification temperature range –40°C to +85°C.

DRIFT

Gain Drift is a measure of the change in the Full Scale Range (FSR) output over the specification temperature range. Gain Drift is expressed in parts per million per degree Celsius (ppm/°C).

Bipolar Zero Drift is measured with a data input of 800_{HEX}. The D/A is configured for bipolar output. Bipolar Zero Drift is expressed in parts per million of Full Scale Range per degree Celsius (ppm of FSR/°C).

SETTLING TIME

Settling Time is the total time (including slew time) for the output to settle to within an error band around its final value after a change in input. Settling times are specified to ±0.01% of Full Scale Range (FSR) for two conditions: one for a FSR output change of 20V (25kΩ feedback) and one for a 1LSB change. The 1LSB change is measured at the Major Carry ($7FF_{HEX}$ to 800_{HEX}, and 800_{HEX} to $7FF_{HEX}$), the input code transition at which worst-case settling time occurs.

OPERATION

INTERFACE LOGIC

The bus interface logic of the DAC2813 consists of two independently addressable latches in two ranks for each D/A converter. The first rank consists of one 12-bit input latch which can be loaded directly from a 12- or 16-bit microprocessor/microcontroller bus. The input latch holds data temporarily before it is loaded into the second latch, the D/A latch. This double buffered organization permits simultaneous update of all D/As.

All latches are level-triggered. Data present when the control signals are logic "0" will enter the latch. When the control signals return to logic "1", the data is latched.

CAUTION: DAC2813 was designed to use $\overline{WR}$ as the fast strobe. WR/ has a much faster logic path than $\overline{EN_X}$ (or LDAC). Therefore, if one permanently wires $\overline{WR}$ to DCOM and uses only $\overline{EN_X}$ to strobe data into the latches, the DATA

HOLD time will be long, approximately 20ns to 30ns and this time will vary considerably in this range from unit to unit. DATA HOLD time using $\overline{WR}$ is 5ns max.

RESET FUNCTION

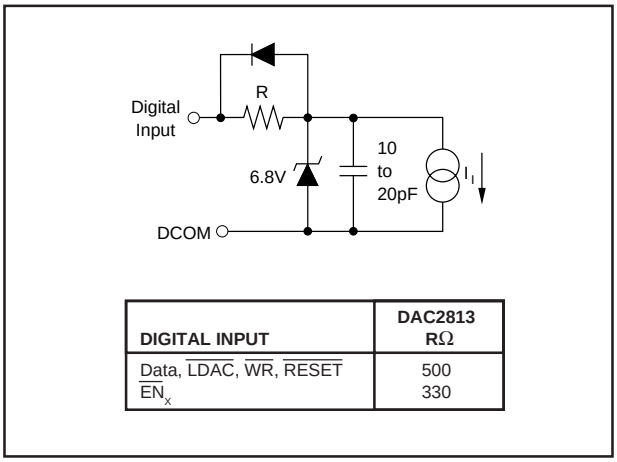
The Reset function resets only the D/A latch. Therefore, after a RESET, good data must be written to **all** the input latches before an $\overline{LDAC}$ – $\overline{WR}$ command is issued. Otherwise, old data or unknown data is present in the input latches and will be transferred to the D/A latch producing an analog output value that may be unwanted.

LOGIC INPUT COMPATIBILITY

DAC2813 digital inputs are TTL compatible (1.4V switching level) over the operating range of $+V_{CC}$. Each input has low leakage and high input impedance. Thus the inputs are suitable for being driven by any type of 5V logic. An equivalent circuit of a digital input is shown in Figure 1.

Open DATA input lines will float to 7V or more. Although this will not harm the DAC2813, current spikes will occur in the input lines when a logic 0 is asserted and, in addition, the speed of the interface will be slower. A digital output driving a DATA input line of the DAC2813 must not drive, **or let the DATA input float**, above +5.5V. Unused DATA inputs should be connected to DCOM.

Unused CONTROL inputs should be connected to a voltage greater than +2V but not greater than +5.5V. If this voltage is not available, the control inputs can be connected to $+V_{CC}$ through a 100kΩ resistor to limit the input current.



DIGITAL INPUT	DAC2813 RΩ
Data, $\overline{LDAC}$, $\overline{WR}$, $\overline{RESET}$	500
$\overline{EN}_x$	330

FIGURE 1. Equivalent Digital Input Circuit.

INPUT CODING

DAC2813 accepts positive-true binary input codes. Input coding for bipolar analog outputs is Bipolar Offset Binary (BOB), where an input code of 000_{HEX} gives a minus full-scale output, an input of FFF_{HEX} gives an output 1LSB below positive full scale, and zero occurs for an input code of 800_{HEX}.

DAC2813 can be used with two's complement coding if a logic inverter is used ahead of the MSB input (DB11).

DAC2813 can be connected for 0 to +10V unipolar operation by using the BPO resistors, plus a 100Ω series resistor, in parallel with the internal feedback resistor. In this case, an input code of 000_{HEX} gives zero volt output, an input of FFF_{HEX} gives an output 1LSB below positive full scale.

INTERNAL/EXTERNAL REFERENCE USE

DAC2813 contains a +10V ±50mV voltage reference, $V_{REF\ OUT}$. $V_{REF\ OUT}$ is available to drive external loads sourcing up to 2mA. The load current should be constant, otherwise the gain (and bipolar offset, if connected) of the D/A converters will vary.

For DAC2813 $V_{REF\ OUT}$ must be connected to $V_{REF\ IN\ 1}$ and $V_{REF\ IN\ 2}$ through gain adjust resistors with a nominal value of 500Ω. Trim potentiometers with a nominal value of 1000Ω can be used to provide adjustment to zero gain error.

It is possible to use references other than +10V. The recommended range of reference voltage is from +8V to +11V, which allows both 8.192V and 10.24V ranges to be used. However, DAC2813 is optimized for fixed-reference applications. If the reference voltage is expected to time-vary over a wide range, a CMOS multiplying D/A is a better choice.

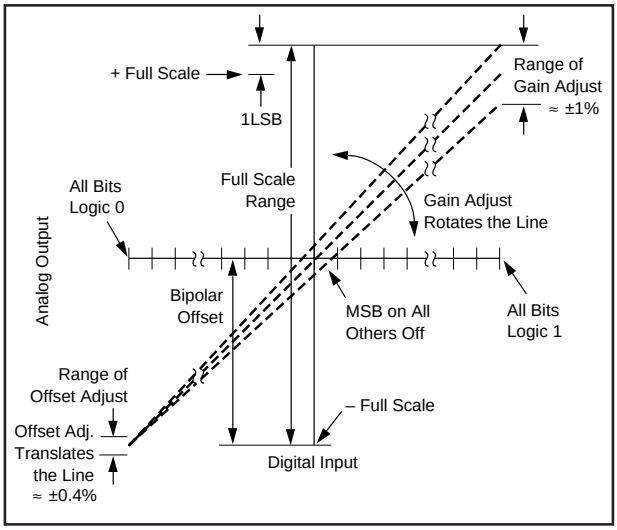


FIGURE 2. Relationship of Offset and Gain Adjustments for a Bipolar D/A Converter.

DIGITAL INPUT	ANALOG OUTPUT	
	UNIPOLAR 0 TO +10V	BIPOLAR ±10V
FFF_{HEX}	+9.9976V	+9.9951V
800_{HEX}	+5.0000V	0.0000V
$7FF_{HEX}$	+4.9976V	–0.0049V
000_{HEX}	0.0000V	–10.0000V
1LSB	2.44mV	4.88mV

TABLE III. Analog Output Calibration Values.

GAIN AND OFFSET ADJUSTMENTS

Figure 2 illustrates the relationship of offset and gain adjustments to a bipolar connected D/A converter. Offset should be adjusted first to avoid interaction of adjustments.

Offset Adjustment

For bipolar analog output operation, apply digital input code 000_{HEX} to produce the maximum negative output and adjust the offset potentiometer for –10.000V. See Table III for calibration values and codes.

Gain Adjustment

For either unipolar or bipolar operation, apply digital input code FFF_{HEX} gives the maximum positive voltage output. Adjust the gain potentiometer for this positive full scale voltage. See Table III for calibration values.

INSTALLATION

POWER SUPPLY CONNECTIONS

Power supply decoupling capacitors should be added as shown in Figure 4. Best settling time performance occurs using a 1 to 10µF tantalum capacitor at $–V_{CC}$. Applications with less critical settling time may be able to use 0.01µF at $–V_{CC}$ as well as at $+V_{CC}$. The capacitors should be located close to the package.

DAC2813 features separate digital and analog power supply returns to permit optimum connections for low noise and high speed performance. It is recommended that both DIGITAL COMMON (DCOM) and ANALOG COMMON (ACOM) be connected directly to a ground plane under the package. If a ground place is not used, connect the ACOM and DCOM pins together close to the package. Since the reference point for V_{OUT} and $V_{REF\ OUT}$ is the ACOM pin, it is also important to connect the load directly to the ACOM pin. The change in current in the ACOM pin due to an input date word change from 000_{HEX} to FFF_{HEX} is only 1mA for each D/A converter.

OUTPUT VOLTAGE SWING AND RANGE CONNECTIONS

DAC2813 output amplifiers provide a ±10V output swing while operating on supplies as low as ±12V ±5%.

DAC2813 is internally connected to provide ±10V output when the bipolar offset pins BPO1 and/or BPO2 are connected, through 100Ω resistors, to $V_{REF\ OUT}$. For a unipolar 0 to +10V output, the BPO resisitor, in series with a 100Ω external resistor, may be paralleled with the internal feedback resistor to provide the correct scaling. The internal feedback resistors (25kΩ) and the bipolar offset resistor (24.9kΩ) are trimmed to an absolute tolerance of ±2%.

12- AND 16-BIT BUS INTERFACES

DAC2813 data is latched into the input latches of each D/A by asserting low each ENx individually and transferring the data from the bus to each input latch by asserting WR low. All D/A outputs in each package are then updated simultaneously by asserting LDAC and WR low. Be sure and read the CAUTION statement in the LOGIC INPUT COMPATIBILITY section.

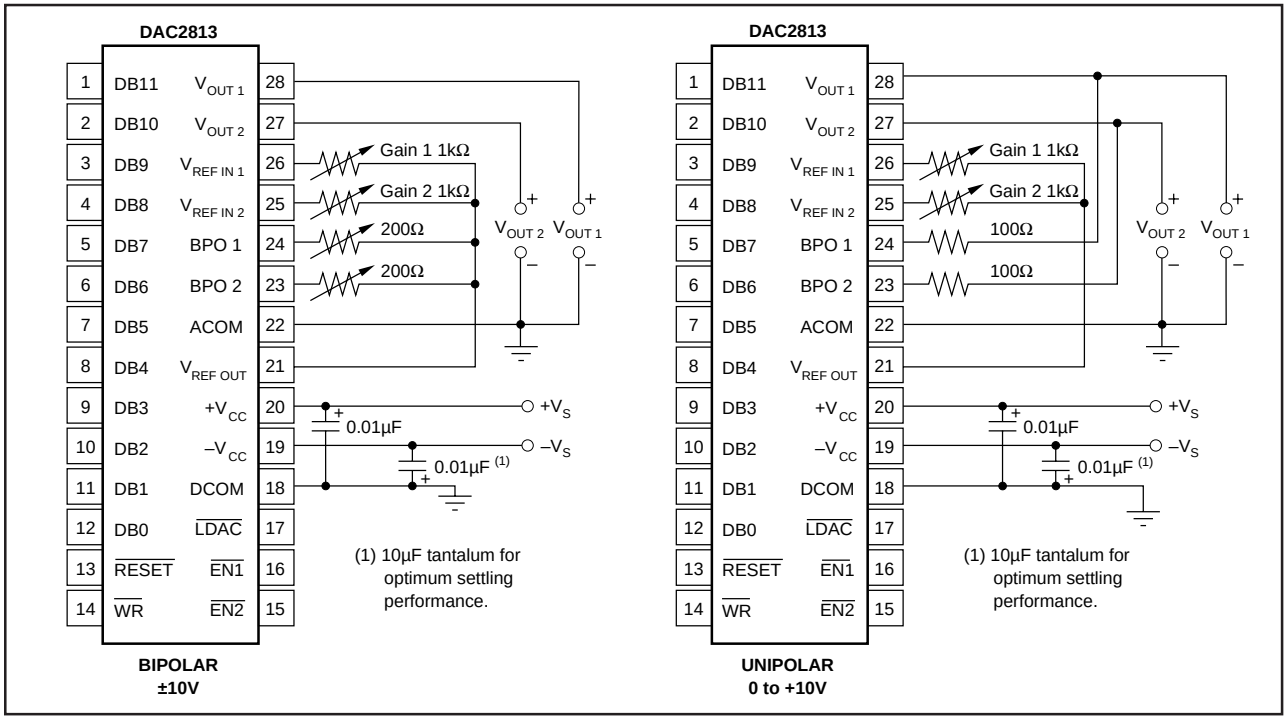


FIGURE 3. DAC2813 Power Supply, Output Range, Gain and Offset Adjust Connections. Unipolar output connected DAC2813s have Gain Adjust only.

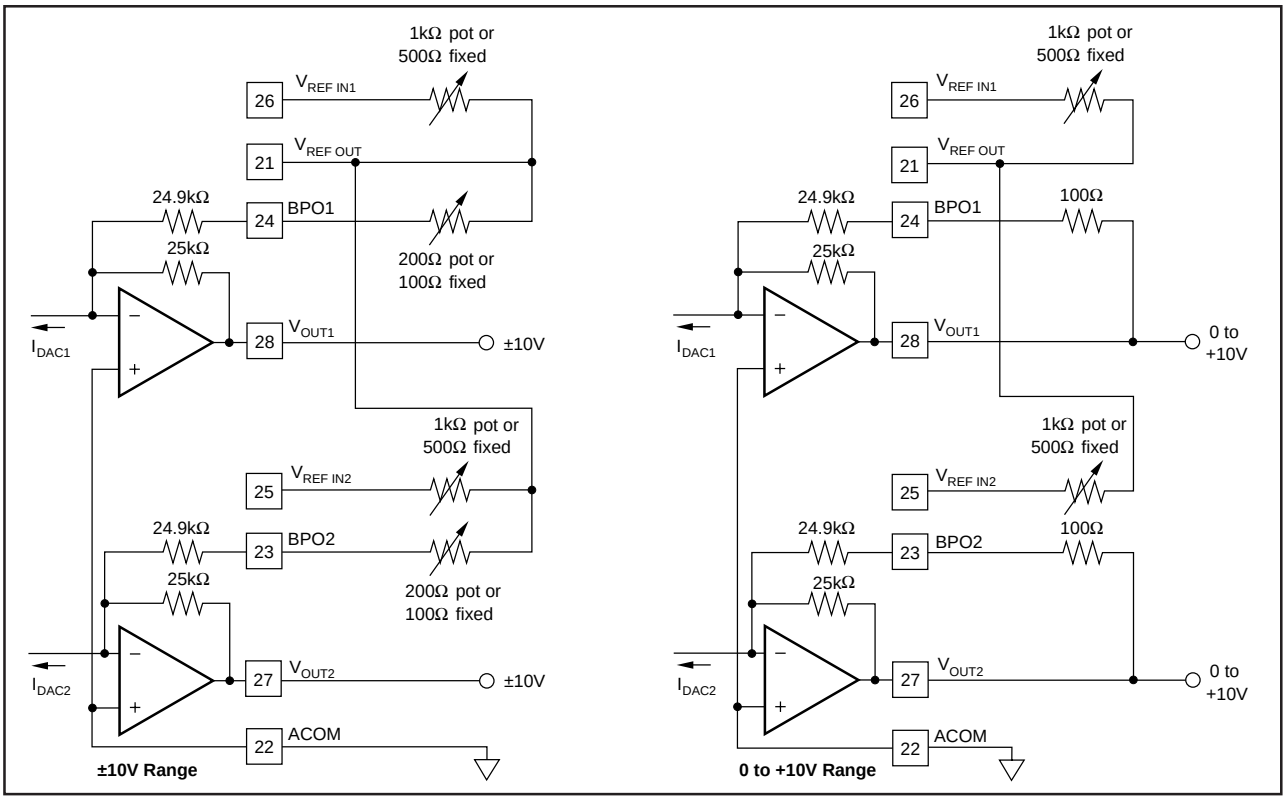


FIGURE 4. DAC2813 Output Amplifier Range Connnections.