19-1300; Rev 0; 10/97

MAXIM

8-Bit Parallel DAC in QSOP-16 Package

General Description

The MAX5480 is a CMOS, 8-bit digital-to-analog converter (DAC) that interfaces directly with most microprocessors. On-chip input latches make the DAC load cycle interface similar to a RAM write cycle, where $\overline{CS}$ and $\overline{WR}$ are the only control inputs required.

Linearity of ±1/2LSB is guaranteed, and power consumption is less than 500µW. Monotonicity is guaranteed over the full operating temperature range.

The MAX5480 can be operated in either voltage-output or current-output mode. It is available in a small 16-pin QSOP package.

Applications

Digitally Adjusted Power Supplies

Programmable Gain

Automatic Test Equipment

Portable, Battery-Powered Instruments

VCO Frequency Control

RF Transmit Control in Portable Radios

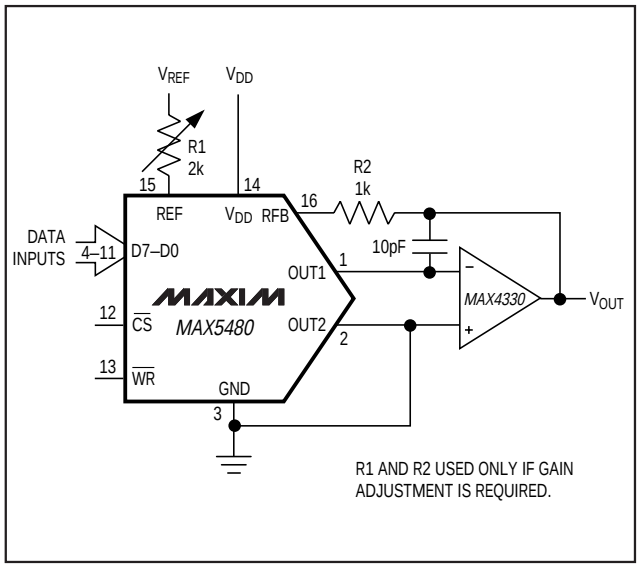
Features

- **QSOP-16 Package (same footprint as SO-8)**
- **Single +5V Supply Operation**
- **VOUT or IOUT Operation**
- **8-Bit Parallel Interface**
- **Guaranteed Monotonic Over Temperature**
- **Low Power Consumption—100µA max**
- **±1/2LSB Linearity Over Temperature**

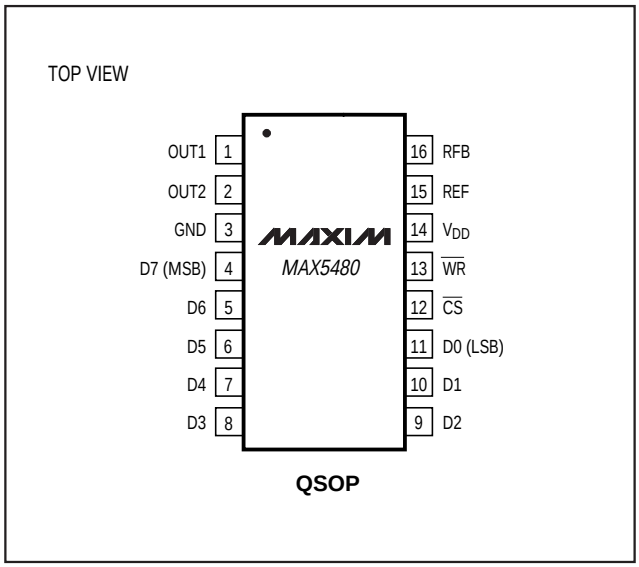
Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE	ERROR (LSB)
MAX5480ACEE	0°C to +70°C	16 QSOP	±1/2
MAX5480BCEE	0°C to +70°C	16 QSOP	±1/2
MAX5480AEEE	-40°C to +85°C	16 QSOP	±1/2
MAX5480BEEE	-40°C to +85°C	16 QSOP	±1/2

Typical Operating Circuit



Pin Configuration



8-Bit Parallel DAC in QSOP-16 Package

ABSOLUTE MAXIMUM RATINGS

V_{DD} to GND .....-0.3V to +17V
REF to GND .....±25V
RFB to GND .....±25V
Digital Inputs to GND .....-0.3V to (V_{DD} + 0.3V)
OUT1, OUT2 to GND.....-0.3V to V_{DD}

Operating Temperature Ranges
MAX5480_CEE.....0°C to +70°C
MAX5480_EEE.....-40°C to +85°C
Storage Temperature Range .....-65°C to +160°C
Continuous Power Dissipation (T_A = +70°C)
MAX5480_ _EE (derate 8.3mW/°C above +70°C) 667mW
Lead Temperature (soldering 10sec) .....+300°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

(V_{DD} = +5V, V_{REF} = +10V, V_{OUT1} = V_{OUT2} = 0V, Circuit of Figure 1, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS			MIN	TYP	MAX	UNITS
DC ACCURACY								
Resolution					8			Bits
Relative Accuracy	INL						±1/2	LSB
Differential Nonlinearity	DNL	All grades guaranteed monotonic over temperature					±1	LSB
Gain Error (Note 1)		T_A = T_{MIN} to T_{MAX}				±1		LSB
Gain Temperature Coefficient (Note 2)						±2		ppm/°C
Supply Rejection	PSR	MAX5480A (Note 3)	T_A = +25°C			0.002	0.08	%FSR/%
			T_A = T_{MIN} to T_{MAX}			0.01	0.16	
		MAX5480B	T_A = +25°C			0.002		
			T_A = T_{MIN} to T_{MAX}			0.01		
Output Leakage Current (I_{OUT1})		V_{REF} = ±10V, DAC code = full scale	T_A = +25°C				±50	nA
			T_A = T_{MIN} to T_{MAX}				±400	
Output Leakage Current (I_{OUT2})		V_{REF} = ±10V, DAC code = zero scale	T_A = +25°C				±50	nA
			T_A = T_{MIN} to T_{MAX}				±400	
REFERENCE INPUT								
Input Resistance	R_{REF}	pin 15 to GND			5	10	20	kΩ
DYNAMIC PERFORMANCE								
Output Current Settling Time to 1/2LSB		D0–D7 = 0V to V_{DD} or V_{DD} to 0V, $\overline{WR}$ = $\overline{CS}$ = 0V, OUT1 load = 100Ω ‖ 13pF	MAX5480A (Note 3)	T_A = +25°C			400	ns
				T_A = T_{MIN} to T_{MAX}			500	
			MAX5480B	T_A = +25°C		250		
AC Feedthrough (OUT1 or OUT2)		V_{REF} = ±10V, 100kHz sine wave, $\overline{WR}$ = $\overline{CS}$ = 0V	MAX5480A (Note 3)	T_A = +25°C			0.25	ns
				T_A = T_{MIN} to T_{MAX}			0.5	
			MAX5480B	T_A = +25°C		0.1		
ANALOG OUTPUTS								
OUT1 Capacitance (Note 3)	C_{OUT1}	D0–D7 = V_{DD}, $\overline{WR}$ = $\overline{CS}$ = 0V					120	pF
		D0–D7 = 0V, $\overline{WR}$ = $\overline{CS}$ = 0V					30	
OUT2 Capacitance (Note 3)	C_{OUT2}	D0–D7 = V_{DD}, $\overline{WR}$ = $\overline{CS}$ = 0V					30	pF
		D0–D7 = 0V, $\overline{WR}$ = $\overline{CS}$ = 0V					120	

ELECTRICAL CHARACTERISTICS (continued)

(V_{DD} = +5V, V_{REF} = +10V, V_{OUT1} = V_{OUT2} = 0V, Circuit of Figure 1, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
DIGITAL INPUTS							
Input High Voltage	V_{IH}			2.4			V
Input Low Voltage	V_{IL}					0.8	V
Input Current	I_{IN}	T_A = +25°C; V_{IN} = 0V to V_{DD}				±1	µA
		T_A = T_{MIN} to T_{MAX}				±10	
Input Capacitance (Note 3)	C_{IN}	D0–D7				8	pF
		$\overline{WR}$, $\overline{CS}$				20	
POWER REQUIREMENTS							
Supply Current	I_{DD}	Digital inputs at 0V or V_{DD}	T_A = +25°C			100	µA
			T_A = T_{MIN} to T_{MAX}			500	
SWITCHING CHARACTERISTICS (Figure 4)							
Chip-Select to Write-Setup Time	t_{CS}	MAX5480A		220			ns
		MAX5480B			35		
Chip-Select to Write-Hold Time	t_{CH}	MAX5480A		0			ns
		MAX5480B			0		
Write Pulse Width	t_{WR}	MAX5480A		220			ns
		MAX5480B			35		
Data-Setup Time	t_{DS}	MAX5480A		170			ns
		MAX5480B			55		
Data-Hold Time	t_{DH}	MAX5480A		10			ns
		MAX5480B			-7		

Note 1: Gain error is measured using internal feedback resistor. Full-scale range (FSR) = V_{REF}.
Note 2: Gain TempCo measured from +25°C to T_{MAX} and from +25°C to T_{MIN}.
Note 3: Guaranteed by design.

Pin Description

PIN	NAME	FUNCTION
1	OUT1	R-2R Ladder Output
2	OUT2	R-2R Ladder Output, complement of OUT1
3	GND	Ground
4–11	D7–D0	Data Inputs, D7 is the most significant bit.
12	$\overline{CS}$	Chip Select Input. Active Low.
13	$\overline{WR}$	Write Control Input. Active Low.
14	V_{DD}	Power Supply Input, +5V
15	REF	Reference Voltage Input
16	RFB	Feedback Resistor Connection

8-Bit Parallel DAC in QSOP-16 Package

Detailed Description

The MAX5480 is an 8-bit multiplying digital-to-analog converter (DAC) that consists of a thin-film R-2R resistor array with CMOS current steering switches. Figure 3 shows a simplified schematic of the DAC. The inverted R-2R ladder divides the voltage or current reference in a binary manner among the eight steering switches. The magnitude of the current appearing at either OUT terminal depends on the number of switches selected; therefore, the output is an analog representation of the digital input. The two OUT terminals must be held at the same potential so a constant current is maintained in each ladder leg. This makes the REF input current independent of switch state and also ensures that the MAX5480 maintains its excellent linearity performance.

Interface-Logic Information

Mode Selection

The inputs $\overline{CS}$ and $\overline{WR}$ control the MAX5480's operating mode (see Table 1).

Write Mode

When $\overline{CS}$ and $\overline{WR}$ are both low, the MAX5480 is in write mode, and its analog output responds to data activity at the D0–D7 data-bus inputs. In this mode, the data latches are transparent (see Tables 2 and 3).

Hold Mode

In hold mode, the MAX5480 retains the data that was present on D0–D7 just prior to $\overline{CS}$ or $\overline{WR}$ assuming a high state. The analog output remains at the value corresponding to the digital code locked in the data latch.

Applications Information

Using the MAX5480 in Voltage-Output Mode (Single Supply)

The MAX5480 can be used either as a current-output DAC (Figures 1 and 6) or as a voltage-output DAC (Figures 2 and 5).

To use the MAX5480 in voltage mode, connect OUT1 to the reference input and connect OUT2 to ground. REF, now the DAC output, is a voltage source with a constant output resistance of 10kΩ (nominally). This output is often buffered with an op amp (Figure 5).

An advantage of voltage-mode operation is single-supply operation for the complete circuit; i.e., a negative reference is not required for a positive output. It is important to note that the range of the reference is restricted in voltage mode. The reference input (voltage at OUT1) must always be positive and is limited to no more than V_{DD} - 3V. If the reference voltage exceeds this value, linearity is degraded.

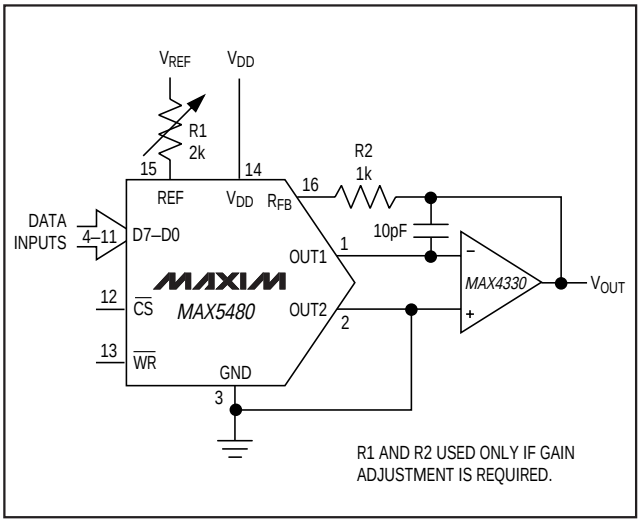


Figure 1. Unipolar Binary Operation (Two-Quadrant Multiplication)

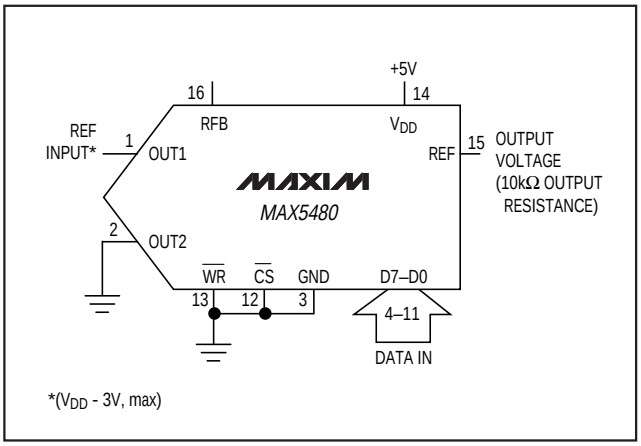


Figure 2. Typical Operating Circuit (Voltage Mode—Unbuffered)

Table 1. Mode-Selection Table

$\overline{CS}$	$\overline{WR}$	MODE	DAC Response
L	L	Write	DAC responds to data bus (D0–D7) inputs.
H X	X H	Hold Hold	Data bus (D0–D7) is locked out; DAC holds last data present when $\overline{CS}$ or $\overline{WR}$ assumed high state.

L = Low State, H = High State, X = Don't Care

Table 2. Unipolar Binary Code Table

DIGITAL INPUT MSB LSB	ANALOG OUTPUT
1 1 1 1 1 1 1 1	$-V_{REF}\left(\frac{255}{256}\right)$
1 0 0 0 0 0 0 1	$-V_{REF}\left(\frac{129}{256}\right)$
1 0 0 0 0 0 0 0	$-V_{REF}\left(\frac{128}{256}\right) = -\frac{V_{REF}}{2}$
0 1 1 1 1 1 1 1	$-V_{REF}\left(\frac{127}{256}\right)$
0 0 0 0 0 0 0 1	$-V_{REF}\left(\frac{1}{256}\right)$
0 0 0 0 0 0 0 0	$-V_{REF}\left(\frac{0}{256}\right) = 0$

NOTE: 1 LSB $= \left(2^{-8}\right)\left(V_{REF}\right) = \frac{1}{256}\left(V_{REF}\right)$

Table 3. Bipolar (Offset Binary) Code Table

DIGITAL INPUT MSB LSB	ANALOG OUTPUT
1 1 1 1 1 1 1 1	$+V_{REF}\left(\frac{127}{128}\right)$
1 0 0 0 0 0 0 1	$+V_{REF}\left(\frac{1}{128}\right)$
1 0 0 0 0 0 0 0	0
0 1 1 1 1 1 1 1	$-V_{REF}\left(\frac{1}{128}\right)$
0 0 0 0 0 0 0 1	$-V_{REF}\left(\frac{127}{128}\right)$
0 0 0 0 0 0 0 0	$-V_{REF}\left(\frac{128}{128}\right)$

NOTE: 1 LSB $= \left(2^{-7}\right)\left(V_{REF}\right) = \frac{1}{128}\left(V_{REF}\right)$

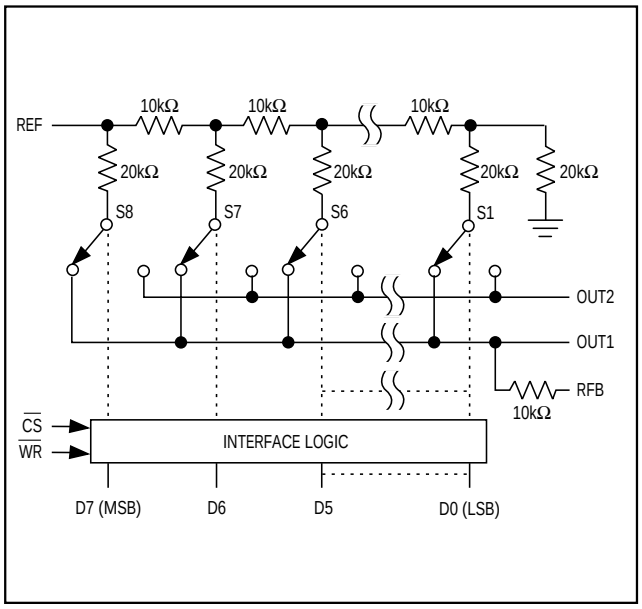
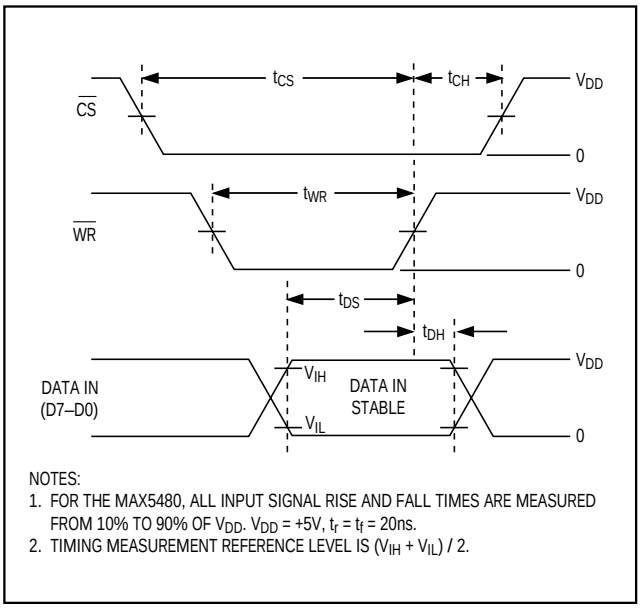


Figure 3. MAX5480 Functional Diagram



NOTES:
1. FOR THE MAX5480, ALL INPUT SIGNAL RISE AND FALL TIMES ARE MEASURED FROM 10% TO 90% OF V_{DD}. V_{DD} = +5V, $t_r = t_f$ = 20ns.
2. TIMING MEASUREMENT REFERENCE LEVEL IS $(V_{IH} + V_{IL}) / 2$.

Figure 4. Write-Cycle Timing Diagram

8-Bit Parallel DAC in QSOP-16 Package

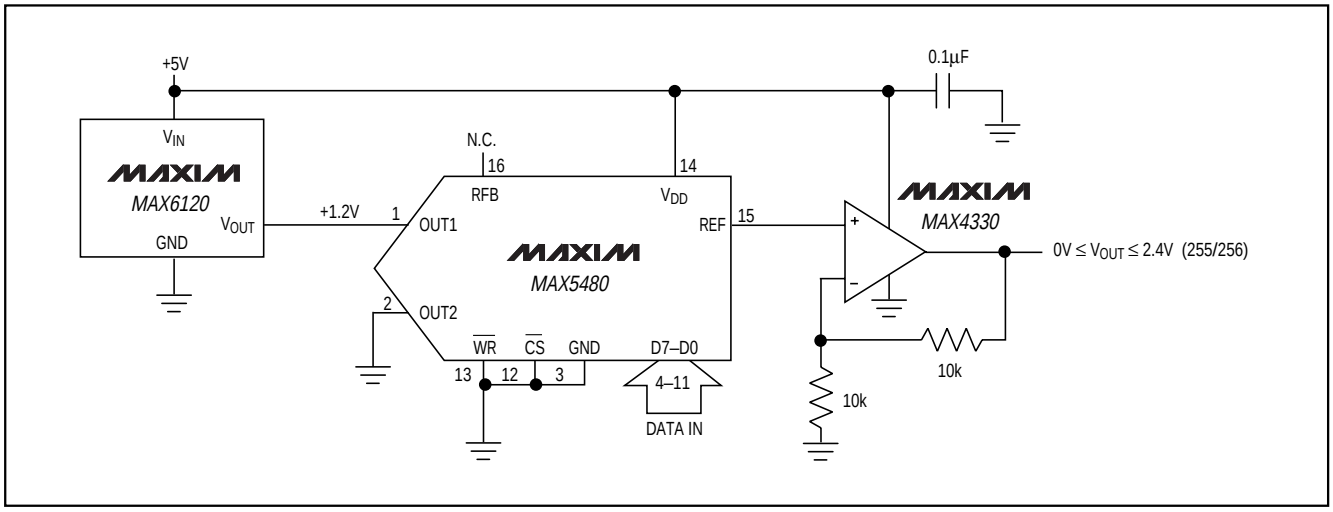


Figure 5. Single-Supply Voltage-Output Mode (Buffered)

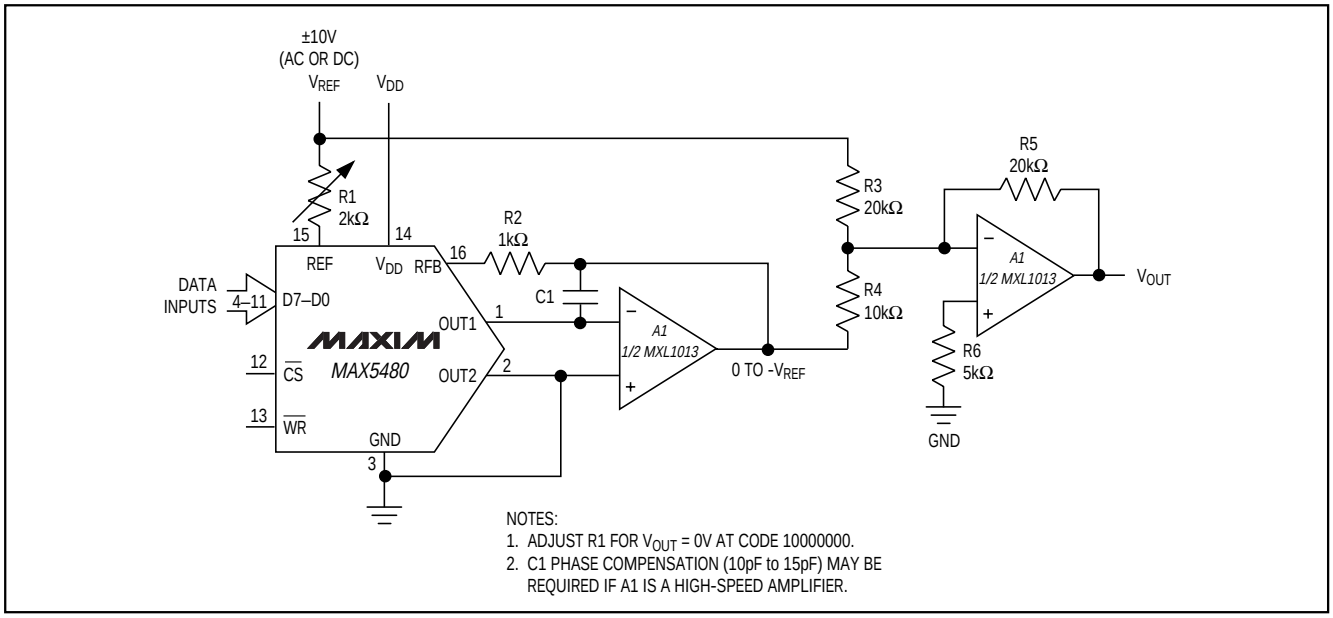


Figure 6. Bipolar (Four-Quadrant) Operation