



# Digitally Programmable Precision Voltage Divider for PGAs

MAX5420/MAX5421

## General Description

The MAX5420 and MAX5421 are digitally programmable precision voltage dividers optimized for use in digitally programmable gain amplifier configurations. The MAX5420/MAX5421 operate from a single +5V supply or dual  $\pm 5V$  supply, and consume only 3 $\mu A$  supply current. These devices consist of a digitally selectable resistor array that provides four precision noninverting gains of 1, 2, 4, and 8 for PGAs. The MAX5420 and MAX5421 achieve a resistor ratio accuracy of 0.025% (MAX542\_A), 0.09% (MAX542\_B), and 0.5% (MAX542\_C). The MAX5421 includes an on-chip matching resistor for op amp bias-current compensation.

The MAX5420 and MAX5421 are available in 8-pin and 10-pin  $\mu$ MAX packages. The devices are specified over the extended temperature range (-40°C to +85°C).

## Applications

- General-Purpose Programmable Noninverting Amplifiers
- Programmable Instrumentation Amplifiers

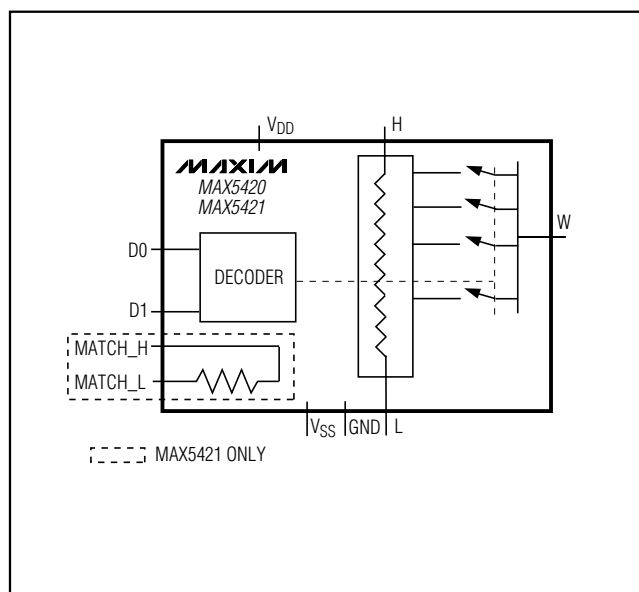
## Features

- ◆ Four Precision Divider Ratios For Noninverting Gains of 1, 2, 4, and 8 in PGAs
- ◆ 0.025%, 0.09%, or 0.5% Ratio Accuracy Guaranteed Over -40°C to +85°C
- ◆ On-Chip Matching Resistor for Op Amp Bias-Current Compensation (MAX5421)
- ◆ 5V Single or  $\pm 5V$  Dual Supply Operation
- ◆ Low 3 $\mu A$  Supply Current
- ◆ CMOS/TTL Logic Compatible 2-Wire Parallel Interface
- ◆ Small 8-Pin and 10-Pin  $\mu$ MAX Packages

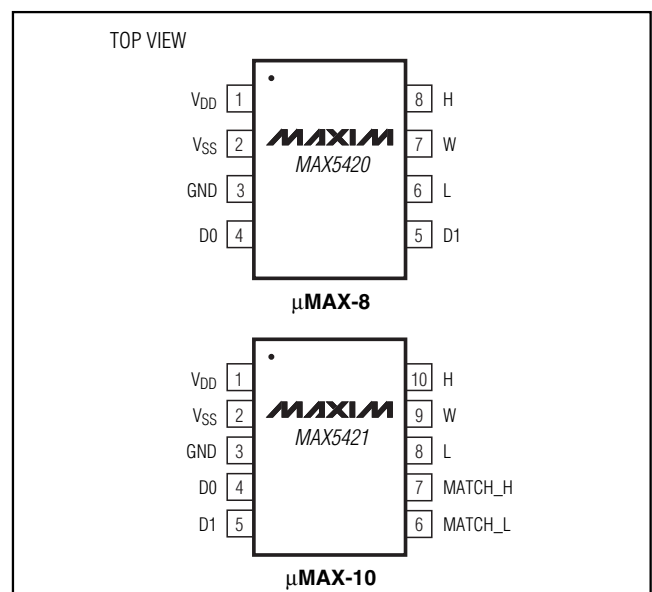
## Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE	GAIN ACCURACY
MAX5420AEUA	-40°C to +85°C	8 $\mu$ MAX	0.025%
MAX5420BEUA	-40°C to +85°C	8 $\mu$ MAX	0.09%
MAX5420CEUA	-40°C to +85°C	8 $\mu$ MAX	0.5%
MAX5421AEUB	-40°C to +85°C	10 $\mu$ MAX	0.025%
MAX5421BEUB	-40°C to +85°C	10 $\mu$ MAX	0.09%
MAX5421CEUB	-40°C to +85°C	10 $\mu$ MAX	0.5%

## Functional Diagram



## Pin Configurations



For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at [www.maxim-ic.com](http://www.maxim-ic.com).

# Digitally Programmable Precision Voltage Divider for PGAs

## ABSOLUTE MAXIMUM RATINGS

V <sub>DD</sub> to GND .....	-0.3V to +6V	Continuous Power Dissipation (T <sub>A</sub> = +70°C)
V <sub>SS</sub> to GND .....	+0.3V to -6V	8-Pin μMAX (derate 4.1mW/°C above +70°C) .....
D0, D1 to GND .....	-0.3V to (V <sub>DD</sub> + 0.3V)	10-Pin μMAX (derate 5.6mW/°C above +70°C) .....
H, L, W, MATCH_ to GND .....	(V <sub>SS</sub> - 0.3V) to (V <sub>DD</sub> + 0.3V)	Operating Temperature Range .....
Input and Output Latchup Immunity .....	±50mA	Storage Temperature Range .....
		Lead Temperature (soldering, 10s) .....

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<sub>DD</sub> = +5V ±5%, V<sub>SS</sub> = -5V ±5% or V<sub>SS</sub> = GND, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Divider Ratio Accuracy		MAX542_A				±0.025	%
		MAX542_B				±0.09	
		MAX542_C				±0.5	
H-to-L Resistance	R <sub>H</sub> L	(Figure 1)			15		kΩ
Input Resistance at H	R <sub>H</sub>				15		kΩ
Input Resistance at W	R <sub>W</sub>	Ratio = 1	V <sub>SS</sub> = -5V		300		Ω
			V <sub>SS</sub> = 0		500		
		Ratio = 2, 4, 8				8	
Capacitance at H, L, W, MATCH_H, MATCH_L	C <sub>ANALOG</sub>				5		pF
Matching Resistor		MAX5421	Ratio = 1	V <sub>SS</sub> = -5V		300	Ω
				V <sub>SS</sub> = 0		500	
			Ratio = 2, 4, 8				8
<b>DYNAMIC PERFORMANCE</b>							
Switching Time	t <sub>S</sub>	V <sub>DD</sub> = +5V, V <sub>SS</sub> = -5V, digital input 0 to +3V, V <sub>W</sub> settles to 0.02% of final value with 2pF capacitive load. Circuit of Figure 2.			0.5		μs
<b>DIGITAL INPUTS</b>							
Input High Voltage	V <sub>IH</sub>			2.4			V
Input Low Voltage	V <sub>IL</sub>				0.8		
Input Leakage Current		D1, D0 = V <sub>DD</sub> or GND				±1	μA
Input Capacitance					5		pF

# Digitally Programmable Precision Voltage Divider for PGAs

MAX5420/MAX5421

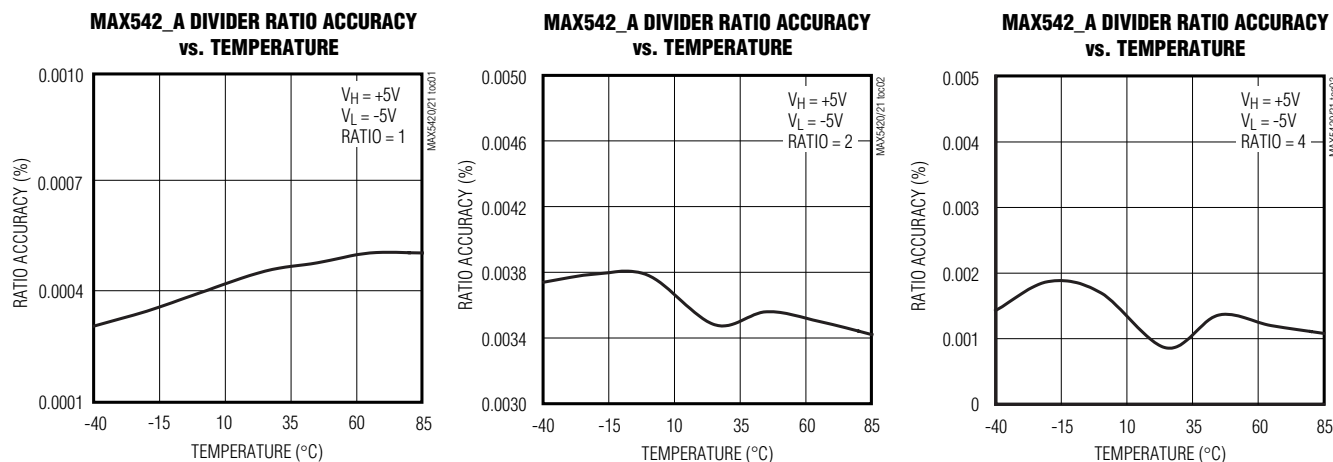
## ELECTRICAL CHARACTERISTICS (continued)

( $V_{DD} = +5V \pm 5\%$ ,  $V_{SS} = -5V \pm 5\%$  or  $V_{SS} = GND$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $T_A = +25^\circ C$ .)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>POWER SUPPLIES</b>						
Positive Supply Voltage	$V_{DD}$		4.75		5.25	V
Negative Supply Voltage	$V_{SS}$		0		-5.25	V
Positive Supply Current	$I_{DD}$	D1, D0 = $V_{DD}$ or GND		3	7	$\mu A$
		D1, D0 = 3V		15	25	
Negative Supply Current	$I_{SS}$	D1, D0 = $V_{DD}$ or GND		3	7	$\mu A$
		D1, D0 = 3V		15	25	
W, H, L, MATCH_L, MATCH_H Voltage Range			$V_{SS}$		$V_{DD}$	V

## Typical Operating Characteristics

( $V_{DD} = +5V$ ,  $V_{SS} = -5V$ , or  $V_{SS} = GND$ ,  $T_A = +25^\circ C$ , unless otherwise noted.) (Note 1)

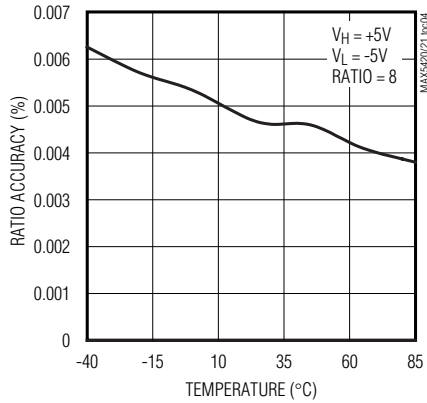


# Digitally Programmable Precision Voltage Divider for PGAs

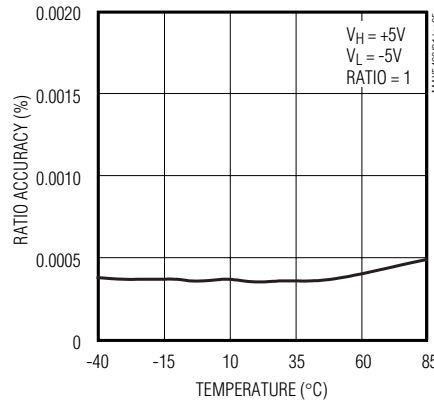
## Typical Operating Characteristics (continued)

( $V_{DD} = +5V$ ,  $V_{SS} = -5V$ , or  $V_{SS} = GND$ ,  $T_A = +25^\circ C$ , unless otherwise noted.) (Note 1)

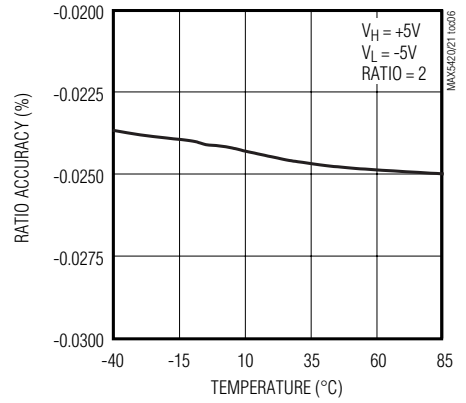
**MAX542\_A DIVIDER RATIO ACCURACY vs. TEMPERATURE**



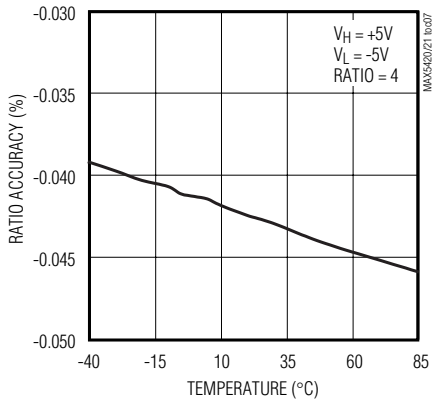
**MAX542\_B DIVIDER RATIO ACCURACY vs. TEMPERATURE**



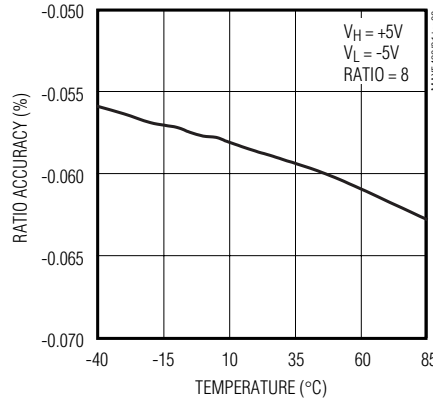
**MAX542\_B DIVIDER RATIO ACCURACY vs. TEMPERATURE**



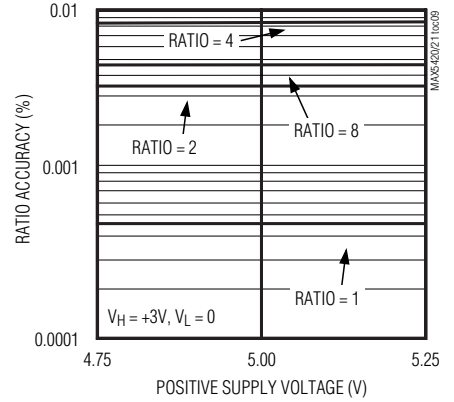
**MAX542\_B DIVIDER RATIO ACCURACY vs. TEMPERATURE**



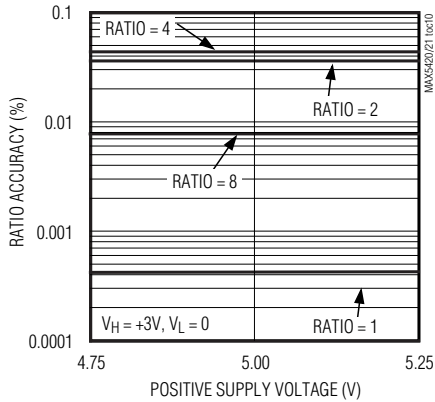
**MAX542\_B DIVIDER RATIO ACCURACY vs. TEMPERATURE**



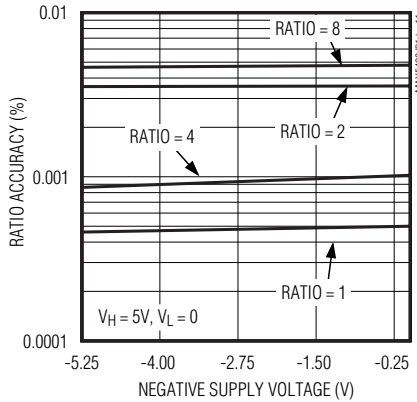
**MAX542\_A RATIO ACCURACY vs. POSITIVE SUPPLY VOLTAGE**



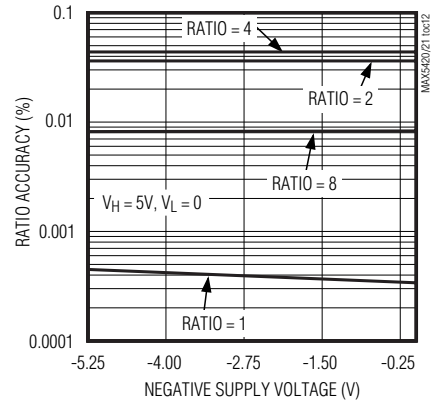
**MAX542\_B RATIO ACCURACY vs. POSITIVE SUPPLY VOLTAGE**



**MAX542\_A RATIO ACCURACY vs. NEGATIVE SUPPLY VOLTAGE**



**MAX542\_B RATIO ACCURACY vs. NEGATIVE SUPPLY VOLTAGE**

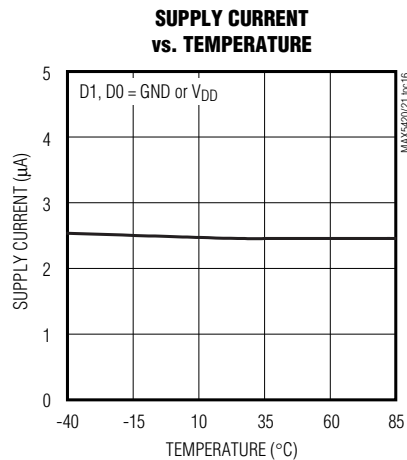
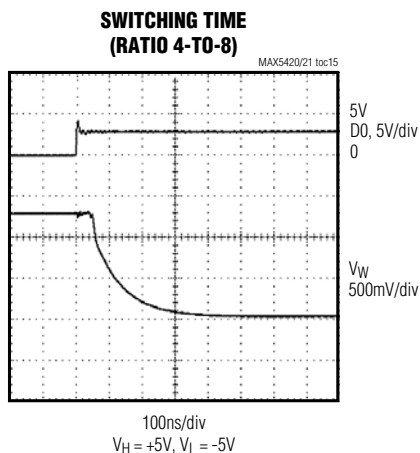
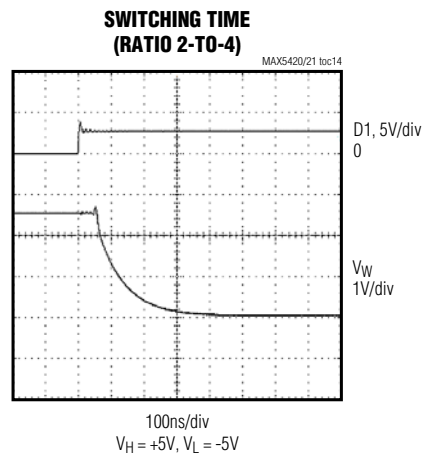
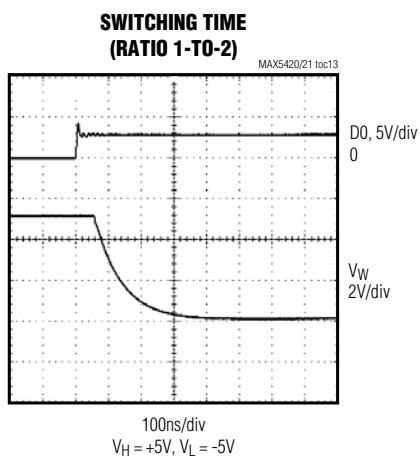


# Digitally Programmable Precision Voltage Divider for PGAs

MAX5420/MAX5421

## Typical Operating Characteristics (continued)

( $V_{DD} = +5V$ ,  $V_{SS} = -5V$ , or  $V_{SS} = GND$ ,  $T_A = +25^\circ C$ , unless otherwise noted.) (Note 1)



**Note 1:** For MAX542\_C accuracy *Typical Operating Characteristics*, refer to MAX542\_B accuracy *Typical Operating Characteristics*.

# Digitally Programmable Precision Voltage Divider for PGAs

## Pin Description

PIN		NAME	FUNCTION
MAX5420	MAX5421		
1	1	V <sub>DD</sub>	Positive Supply Voltage
2	2	V <sub>SS</sub>	Negative Supply Voltage
3	3	GND	Ground
4, 5	4, 5	D0, D1	Digital Control Inputs. Drive D0 and D1 logic high or logic low to set the divider ratio. See <i>Logic Control Truth Table</i> .
6	8	L	Low Terminal of Resistor-Divider
7	9	W	Resistor-Divider Output
8	10	H	High Terminal of Resistor-Divider
—	6	MATCH_L	Matching Resistor Low Terminal
—	7	MATCH_H	Matching Resistor High Terminal

## Detailed Description

The MAX5420/MAX5421 are digitally programmable precision voltage dividers for programmable-gain amplifiers. Operationally, these devices consist of digitally selectable precision resistor-dividers providing noninverting gains of 1, 2, 4, and 8 for PGA applications (see *Functional Diagram* and *Figure 1*).

$$\text{Ratio} = 1 + \frac{R_B}{R_A}$$

The MAX5420/MAX5421 achieve divider ratio accuracy of 0.025% (MAX5420A/MAX5421A), 0.09% (MAX5420B/MAX5421B) or 0.5% (MAX5420C/MAX5421C).

The end-to-end resistance from H to L is 15kΩ. The impedance seen at W is designed to be the same 8kΩ for divider ratios 2, 4, and 8, ensuring excellent impedance matching and constant switching times. In gain of +1 configuration, H is internally connected to W with a typical resistance of 500Ω.

### Matching Resistor (MAX5421)

The MAX5421 includes a matching resistor to compensate for offset voltage due to input bias current of the op amp. The resistance from MATCH\_H to MATCH\_L, equals the resistance seen at W for gains of 2, 4, and 8. In the gain of +1, an internal switch connects MATCH\_H and MATCH\_L. This internal switch matches the impedance of the switch between H and W.

Table 1. Logic Control Truth Table

DIGITAL INPUTS		DIVIDER RATIO
D1	D0	
0	0	1
0	1	2
1	0	4
1	1	8

## Digital Interface Operation

The MAX5420/MAX5421 feature a simple two-bit parallel programming interface. D1 and D0 program the divider ratio setting according to the *Logic Control Truth Table* (Table 1). The digital interface is CMOS/TTL logic compatible.

## Applications Information

### Programmable-Gain Amplifier

The MAX5420/MAX5421 are ideally suited for high-precision PGA applications. The typical application circuit of Figure 3 uses the MAX5421 with matching resistor to compensate for voltage offset due to op amp input bias currents. Use the MAX5420 with an ultra-low input bias current op amp such as the MAX4237 (Figure 4).

### Power Supplies and Bypassing

The MAX5420/MAX5421 operate from dual ±5V supplies, or a single +5V supply. For dual supplies, bypass V<sub>DD</sub> and V<sub>SS</sub> with 0.1μF ceramic capacitors to GND. For single supply, connect V<sub>SS</sub> to GND and bypass V<sub>DD</sub> with a 0.1μF ceramic capacitor to GND.

# Digitally Programmable Precision Voltage Divider for PGAs

MAX5420/MAX5421

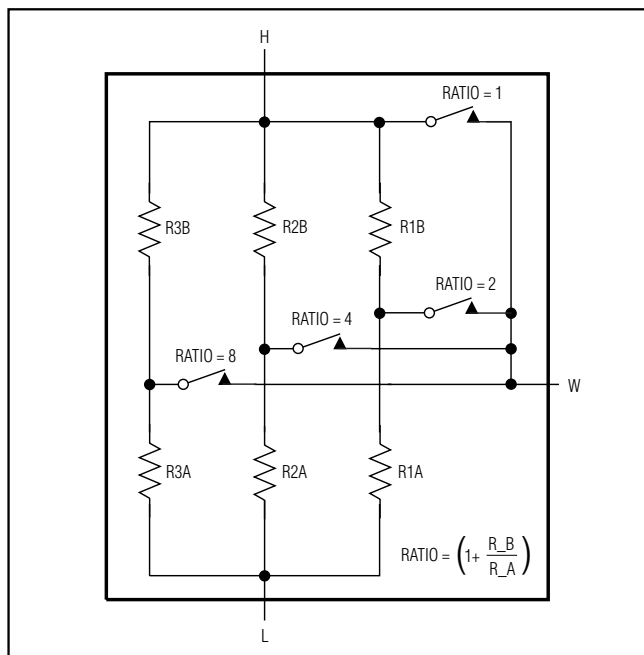


Figure 1. Simplified Functional Diagram

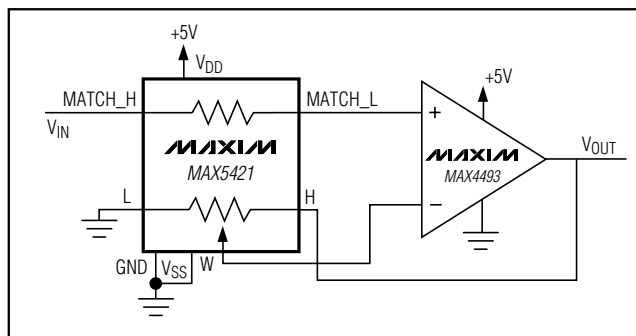


Figure 3. Programmable-Gain Amplifier with Op Amp Bias-Current Matching

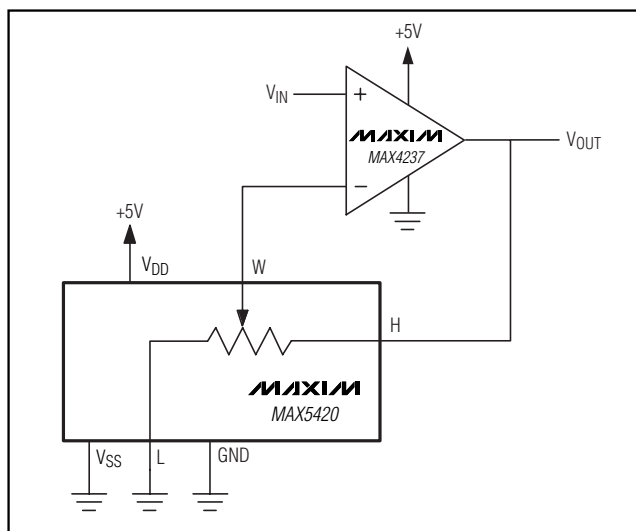


Figure 4. Programmable-Gain Amplifier

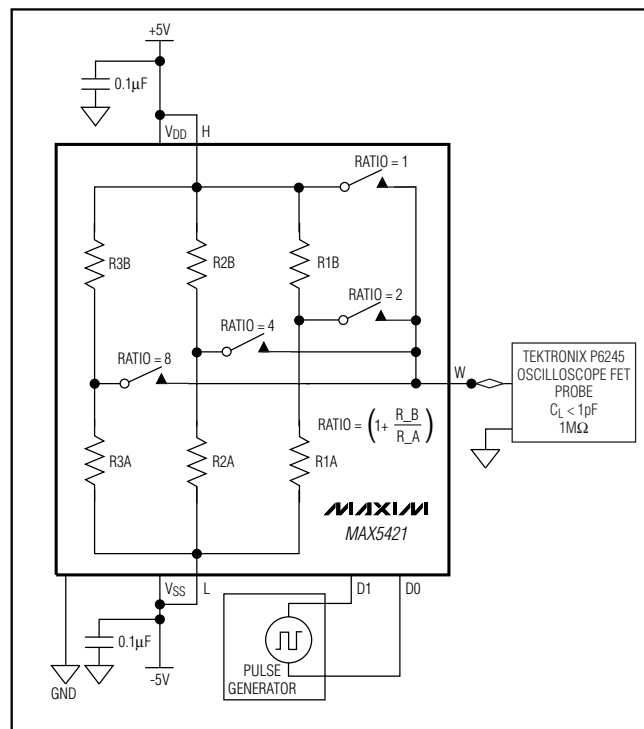


Figure 2. Switching Time Test Circuit

**Switching Time and Layout Concerns**  
 The switching time of the MAX5420/MAX5421 depends on the capacitive loading at W. For best performance, reduce parasitic board capacitance by minimizing the circuit board trace from W to the op amp inverting input, and choose an op amp with low input capacitance.

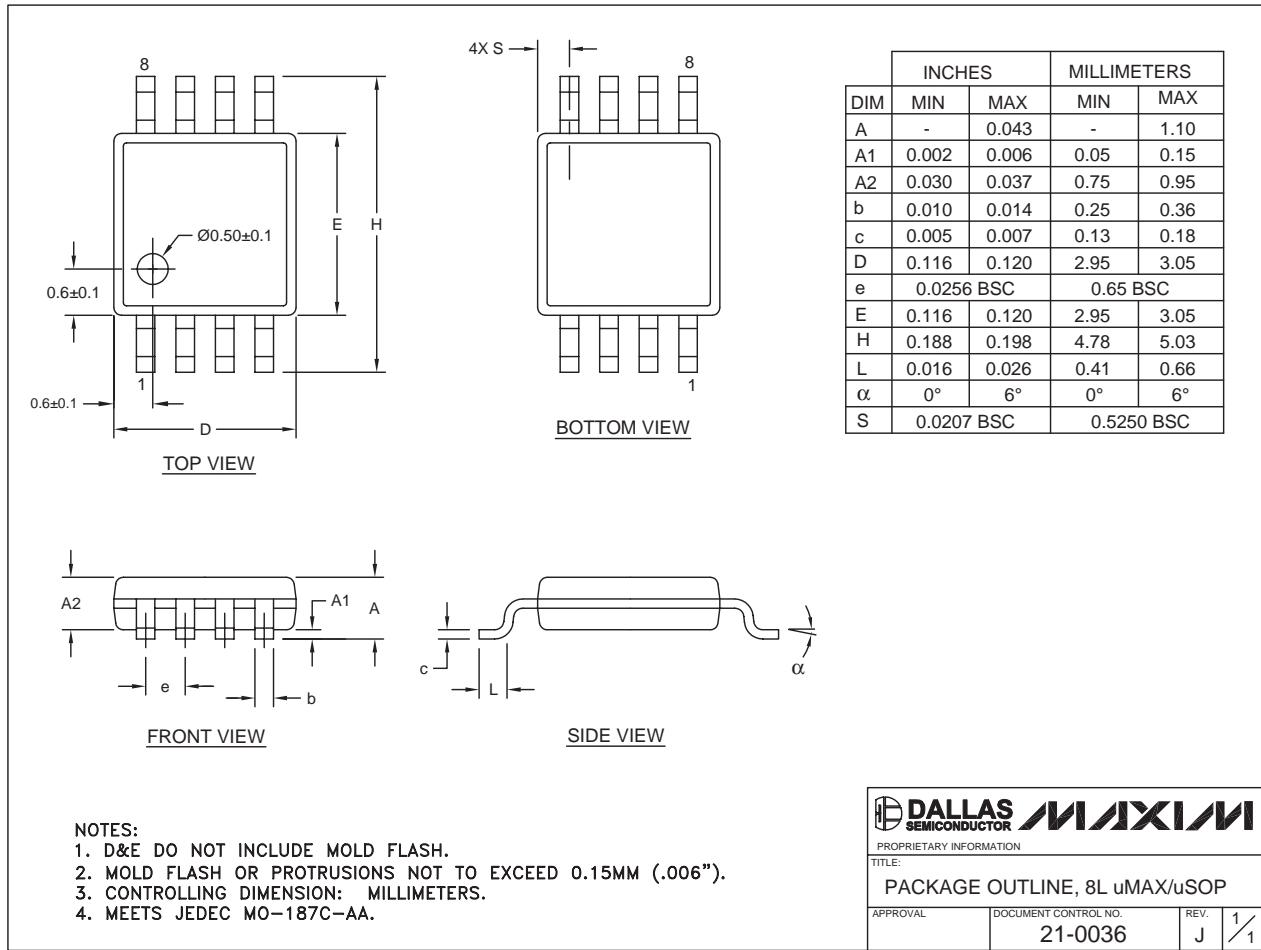
## Chip Information

TRANSISTOR COUNT: 118  
 PROCESS: CMOS

# Digitally Programmable Precision Voltage Divider for PGAs

## Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)



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