

**General Description**

The MAX5486 dual 40kΩ logarithmic taper volume control features a debounced pushbutton up/down interface that controls volume and balance in audio applications. Each potentiometer has 32 log-spaced tap points with a buffered wiper output to replace mechanical potentiometers. An integrated bias generator provides the required  $(V_{DD} + V_{SS})/2$  bias voltage, eliminating the need for costly external op-amp circuits in unipolar audio applications. A mode-indicator LED output indicates volume or balance control. Five integrated LED drivers indicate volume level or balance settings, depending on the status of the mode indicator.

Use the MAX5486 digital inputs with momentary contact single-pole/single-throw (SPST) pushbutton switches. Each input includes internal debounced circuitry and a pullup resistor to  $V_{LOGIC}$ .

The MAX5486 advances the wiper setting once per button push. Maxim's proprietary SmartWiper™ control eliminates the need for a microcomputer to increase the wiper transition rate. The accelerated auto-advance feature provides a wiper-changing rate at 4Hz for holding the control input low for more than 250ms and at 8Hz after 500ms and then at 11Hz after 1000ms (see Table 2).

All of the MAX5486's pushbutton inputs are debounced. The mute input allows a single pushbutton to change between volume control and the -90dB (typ) mute setting. The mode input toggles between volume and balance control. The click-and-pop suppression feature minimizes the audible noise generated by wiper transitions. The typical total harmonic distortion plus noise (THD+N) for the device is 0.003%. The MAX5486 provides a nominal temperature coefficient of 35ppm/°C end-to-end and 5ppm/°C ratiometrically and a nominal resistance of 40kΩ per potentiometer. The MAX5486 is available in a 24-pin TSSOP package and is specified for operation over the -40°C to +85°C extended temperature range.

**Applications**

- Home-Theater Speakers
- Desktop Speakers
- Portable Media Players
- Docking Stations

*SmartWiper is a trademark of Maxim Integrated Products, Inc.*

**Features**

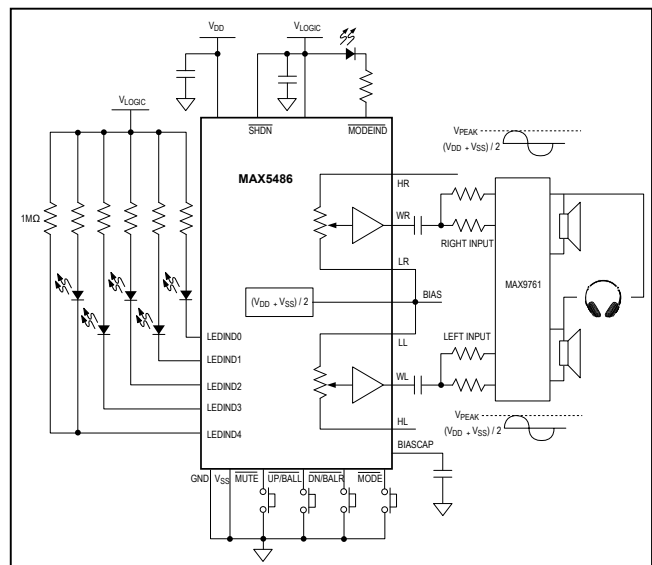
- Debounced Pushbutton Interface
- SmartWiper Control Advances Wiper Rate
- Low-Power Wiper Buffers Provide 0.003% THD+N
- Bias Generator Eliminates External Op Amps
- Five-Segment LED Volume/Balance Indicator
- Clickless Switching
- Logarithmic Taper Volume Control with (31) 2dB Steps
- Single +2.7V to +5.5V or Dual ±2.7V Supply Voltage Operation
- Power-On Reset to -12dBFS Wiper Position
- MUTE Function Toggles to 90dB (typ)
- Low 1µA Shutdown Supply Current
- 40kΩ End-to-End Fixed Resistance Value
- Small, 24-Pin TSSOP Package

**Ordering Information**

PART	TEMP RANGE	PIN-PACKAGE
MAX5486EUG+	-40°C to +125°C	24 TSSOP

+Denotes a lead(Pb)-free/RoHS-compliant package.

**Typical Operating Circuit**



**Absolute Maximum Ratings**

SHDN, MODE, MUTE, UP/BALL, and DN/BALR to GND..... -0.3V to the lower of (V<sub>LOGIC</sub> + 0.3V and +6V)  
 H<sub>-</sub>, L<sub>-</sub>, W<sub>-</sub>, BIASCAP, BIAS to GND ..... -0.3V to the lower of (V<sub>DD</sub> + 0.3V and +6V)  
 LEDIND<sub>-</sub>, MODEIND<sub>-</sub> to GND ..... -0.3V to +6V  
 V<sub>LOGIC</sub> to GND ..... -0.3V to +6V  
 V<sub>DD</sub> to GND ..... -0.3V to +6V  
 V<sub>DD</sub> to V<sub>LOGIC</sub> ..... -6V to +6V  
 GND to V<sub>SS</sub> ..... -0.3V to +6V  
 V<sub>DD</sub> to V<sub>SS</sub> ..... -0.3V to +6V

Average Current into H<sub>-</sub>, L<sub>-</sub>, and W<sub>-</sub>..... ±1mA  
 Maximum Continuous Current into H<sub>-</sub>, L<sub>-</sub>..... ±4mA  
 Input and Output Latchup Immunity..... ±200mA  
 Continuous Power Dissipation (T<sub>A</sub> = +70°C)  
 24-Pin TSSOP (derate 8.3mW/°C above +70°C)..... 657mW  
 Operating Temperature Range..... -40°C to +85°C  
 Storage Temperature Range..... -60°C to +150°C  
 Maximum Junction Temperature ..... +150°C  
 Lead Temperature (soldering, 10s) ..... +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<sub>DD</sub> = +2.7V to +5.5V, V<sub>SS</sub> = GND = 0V, 2.7V ≤ (V<sub>DD</sub> - V<sub>SS</sub>) ≤ 5.5V, C<sub>BIASCAP</sub> = 1μF, BIAS = 3kΩ to GND, V<sub>LOGIC</sub> = +2.7V to V<sub>DD</sub>, V<sub>H-</sub> = V<sub>DD</sub> - 0.15V, V<sub>L-</sub> = (V<sub>DD</sub> - V<sub>SS</sub>)/2, SHDN = MUTE = V<sub>LOGIC</sub>, all LED outputs open, pushbutton interface inactive, V<sub>H</sub> = V<sub>BIAS</sub> + 1V<sub>RMS</sub>, V<sub>BIAS</sub> = (V<sub>DD</sub> - V<sub>SS</sub>)/2, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise specified. Typical values are at T<sub>A</sub> = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>RESISTOR LADDER</b>						
End-to-End Resistance	R			40		kΩ
Absolute Tolerance				±0.25		dB
Tap-to-Tap Tolerance		(Note 2)		±0.1		dB
<b>VOLUME CONTROL</b>						
Total Harmonic Distortion Plus Noise	THD+N	V <sub>DD</sub> = 5V, V <sub>SS</sub> = 0V, V <sub>H</sub> = (V <sub>DD</sub> /2) + 1V <sub>RMS</sub> , V <sub>L</sub> = V <sub>DD</sub> /2, 1kHz, tap at top, R <sub>L</sub> = 10kΩ to V <sub>L</sub> = V <sub>DD</sub> /2, 20Hz to 20kHz		0.003		%
		V <sub>DD</sub> = 5V, V <sub>SS</sub> = 0V, V <sub>H</sub> = (V <sub>DD</sub> /2) + 1V <sub>RMS</sub> , V <sub>L</sub> = V <sub>DD</sub> /2, 1kHz, tap at top, R <sub>L</sub> = Ω to V <sub>L</sub> = V <sub>DD</sub> /2, 20Hz to 20kHz		0.001		
		V <sub>DD</sub> = 5V, V <sub>SS</sub> = 0V, V <sub>H</sub> = (V <sub>DD</sub> /2) + 1.5V <sub>RMS</sub> , V <sub>L</sub> = V <sub>DD</sub> /2, 1kHz, tap at top, R <sub>L</sub> = 10kΩ to V <sub>L</sub> = V <sub>DD</sub> /2, 20Hz to 20kHz		0.012		
Channel Isolation		V <sub>DD</sub> = +2.7V, V <sub>SS</sub> = -2.7V, V <sub>BIAS</sub> = GND		100		dB
Interchannel Matching				±0.5		dB
Mute Attenuation		SHDN = V <sub>DD</sub>		90		dB
Power-Supply Rejection Ratio	PSRR	Input referred, 217Hz, 100mV <sub>P-P</sub> on V <sub>DD</sub>		72		dB
H Terminal Capacitance	C <sub>H</sub>			5		pF
L Terminal Capacitance	C <sub>L</sub>			7		pF
End-to-End Resistance Temperature Coefficient				35		ppm/°C
Ratiometric Resistance Temperature Coefficient				5		ppm/°C
Bandwidth, -3dB	f <sub>CUTOFF</sub>	C <sub>W</sub> = 50pF		100		kHz

**Electrical Characteristics (continued)**

( $V_{DD} = +2.7V$  to  $+5.5V$ ,  $V_{SS} = GND = 0V$ ,  $2.7V \leq (V_{DD} - V_{SS}) \leq 5.5V$ ,  $C_{BIASCAP} = 1\mu F$ ,  $BIAS = 3k\Omega$  to GND,  $V_{LOGIC} = +2.7V$  to  $V_{DD}$ ,  $V_{H\_} = V_{DD} - 0.15V$ ,  $V_{L\_} = (V_{DD} - V_{SS})/2$ ,  $SHDN = MUTE = V_{LOGIC}$ , all LED outputs open, pushbutton interface inactive,  $V_H = V_{BIAS} + 1V_{RMS}$ ,  $V_{BIAS} = (V_{DD} - V_{SS})/2$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise specified. Typical values are at  $T_A = +25^\circ C$ .) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Output Noise	$e_N$	20Hz to 20kHz, $V_H = V_L = V_{DD}/2 = AC$ ground, tap = -6dB		2.2		$\mu V_{RMS}$
<b>WIPER BUFFER</b>						
Output Voltage Swing	$V_O$	$R_L = 3k\Omega$ to $V_{BIAS}$		$V_{DD} - 0.3V$		V
Output Current			3			mA
Output Current	$R_{OWB}$			1	10	$\Omega$
DC Offset	$V_{OS}$			$\pm 2$	$\pm 14$	mV
<b>INTEGRATED BIAS GENERATOR</b>						
Output Voltage		$R_L > 100k\Omega$	$(V_{DD} + V_{SS})/2 - 20mV$	$(V_{DD} + V_{SS})/2$	$(V_{DD} + V_{SS})/2 + 20mV$	V
Power-Supply Rejection Ratio		At 1kHz, 100mV <sub>P-P</sub> on $V_{DD}$		60		dB
Minimum Load Resistance				3		k $\Omega$
Maximum Load Capacitance				100		pF
Output Resistance	$R_{OBR}$			6		$\Omega$
Noise Voltage		20Hz to 20kHz		2.2		$\mu V_{RMS}$
Minimum Output Current				2		mA
<b>CONTACT INPUTS (MUTE, MODE, UP/BALL, DN/BALR)</b>						
Internal Pullup Resistor	$R_{PU}$			42		k $\Omega$
Single-Pulse Input Low Time	$t_{CPW}$	Time required for a single pulse to cause an increment/decrement	16			ms
Repetitive Input Pulse Separation Time	$t_{PWS}$		1			ms
Timeout Period	$t_{WS}$	Click-and-pop suppression inactive		126		ms
Debounce Corner Frequency		Internal analog filter		10		kHz
<b>DIGITAL INPUTS (<math>V_{LOGIC} &gt; 4.5V</math>)</b>						
Input High Voltage	$V_{IH}$	$V_{LOGIC} > 4.5V$	2.4			V
		$V_{LOGIC} < 4.5V$	$0.7 \times V_{LOGIC}$			
Input Low Voltage	$V_{IL}$	$V_{LOGIC} > 4.5V$		0.8		V
		$V_{LOGIC} < 4.5V$		$0.3 \times V_{LOGIC}$		
Input Leakage Current		To GND for inputs with internal pullup resistors			$\pm 1$	$\mu A$
Input Capacitance				5		pF
Digital Clock Feedthrough		$f_{CLK} = 1Hz$ to 40Hz, tap = -6dB		-90		dB

**Electrical Characteristics (continued)**

( $V_{DD} = +2.7V$  to  $+5.5V$ ,  $V_{SS} = GND = 0V$ ,  $2.7V \leq (V_{DD} - V_{SS}) \leq 5.5V$ ,  $C_{BIASCAP} = 1\mu F$ ,  $BIAS = 3k\Omega$  to GND,  $V_{LOGIC} = +2.7V$  to  $V_{DD}$ ,  $V_{H\_} = V_{DD} - 0.15V$ ,  $V_{L\_} = (V_{DD} - V_{SS})/2$ ,  $\overline{SHDN} = MUTE = V_{LOGIC}$ , all LED outputs open, pushbutton interface inactive,  $V_H = V_{BIAS} + 1V_{RMS}$ ,  $V_{BIAS} = (V_{DD} - V_{SS})/2$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise specified. Typical values are at  $T_A = +25^\circ C$ .) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>POWER SUPPLIES</b>						
Positive Power Supply	$V_{DD}$	$V_{SS} = 0V$	2.7		5.5	V
Negative Power Supply	$V_{SS}$	$V_{DD} = +2.7V$	-2.7		0	V
Supply-Voltage Difference		$V_{DD} - V_{SS}$			5.5	V
Analog Supply Current	$I_{DD}$	(Note 3)			1.4	mA
Power-Up Time	$t_{PU}$			126		ms
Logic Supply Voltage	$V_{LOGIC}$	$V_{SS} = 0V$	2.7		$V_{DD}$	V
Logic Active Supply Current	$I_{LOGIC}$	$V_{LOGIC} = V_{DD}$ (Note 4)			200	$\mu A$
Logic Standby Supply Current (Note 3)	$I_{LOGICSTBY}$	$V_{DD} = +5V$ , $V_{SS} = 0V$			1	$\mu A$
		$V_{DD} = +2.7V$ , $V_{SS} = -2.7V$			1	
Shutdown Current	$I_{SHDN}$	$\overline{V_{SHDN}} = 0V$ , total of all supplies		1		$\mu A$
Shutdown Time/Return from Shutdown	$t_{SHDN}$	After 1st zero crossing		1		ms
<b>LED INDICATORS (LEDIND0–LEDIND4, MODEIND)</b>						
Output Low Voltage	$V_{OL}$	$V_{LOGIC} = 2.7V$ , $I_{SINK} = 10mA$			0.4	V
		$V_{LOGIC} = 5V$ , $I_{SINK} = 10mA$			0.2	
Maximum Output Leakage Current				10		$\mu A$
Output Capacitance				3		pF

**Note 1:** Parameters are 100% production tested at  $+85^\circ C$  and limits through the temperature range are guaranteed by design.

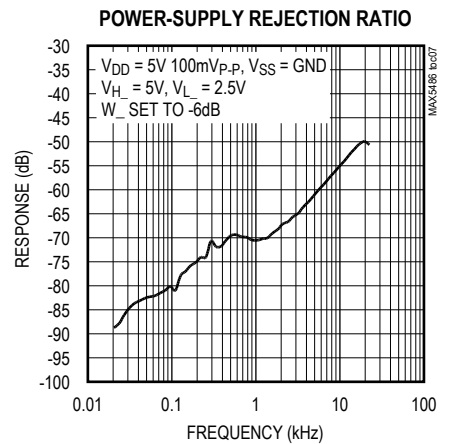
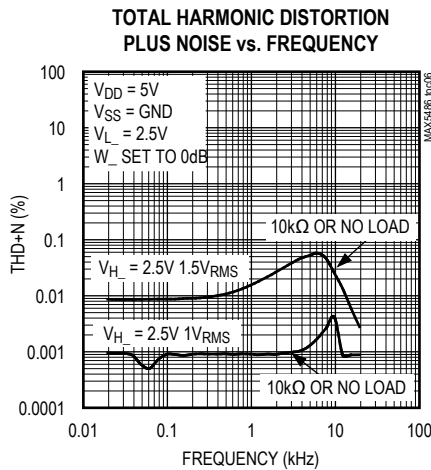
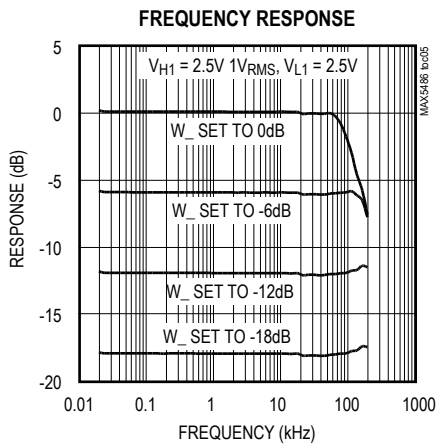
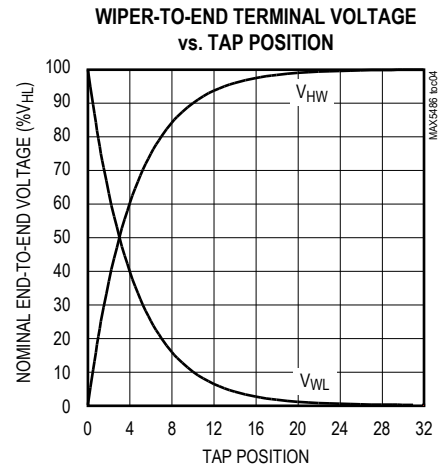
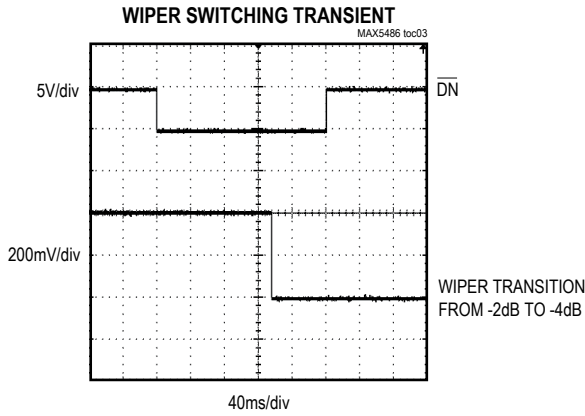
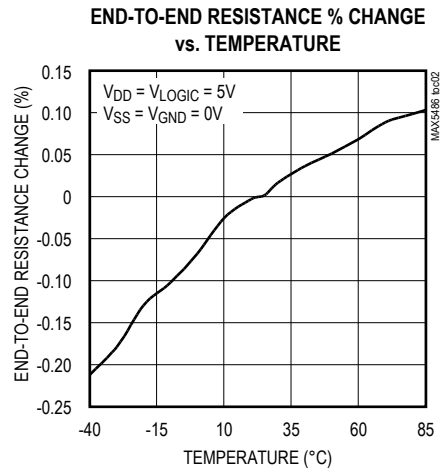
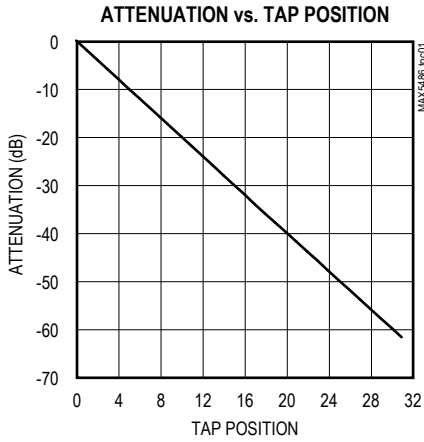
**Note 2:** Tap-to-tap tolerance is the error in voltage change between successive tap positions.

**Note 3:** Supply current measured while wiper position is fixed.

**Note 4:** One button pressed.

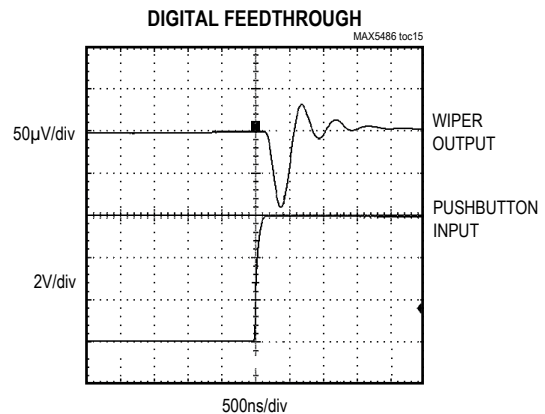
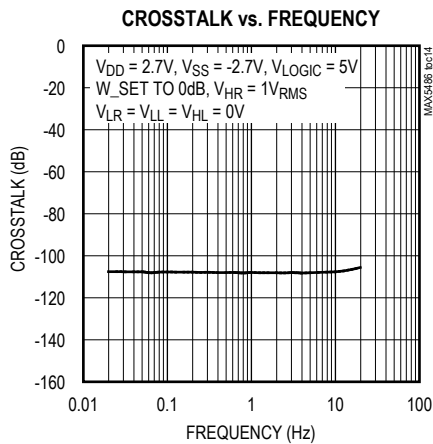
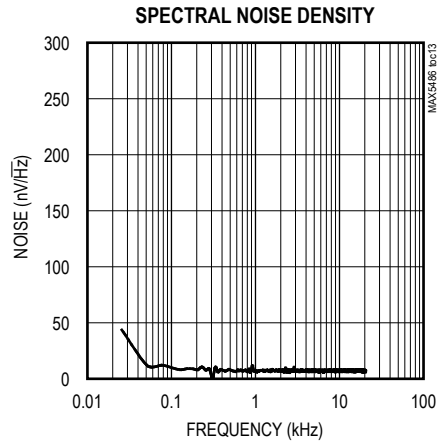
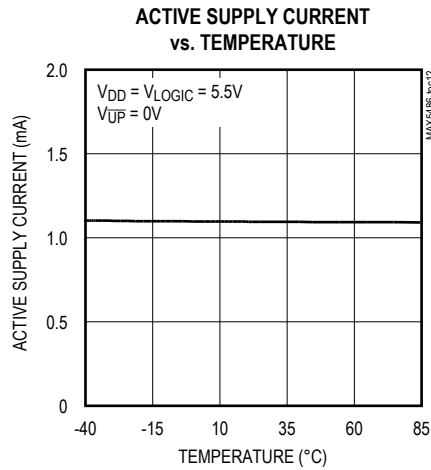
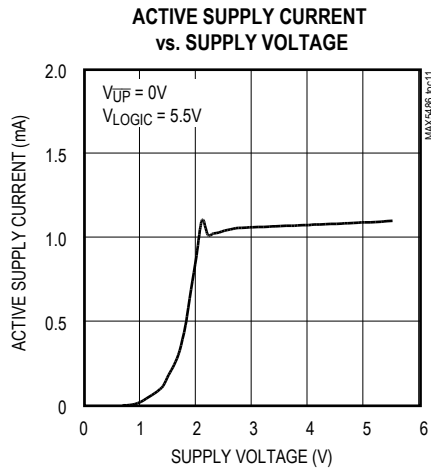
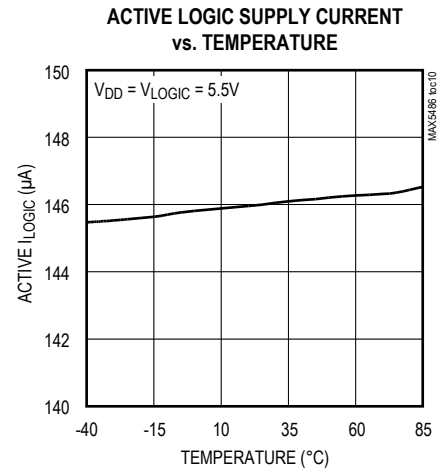
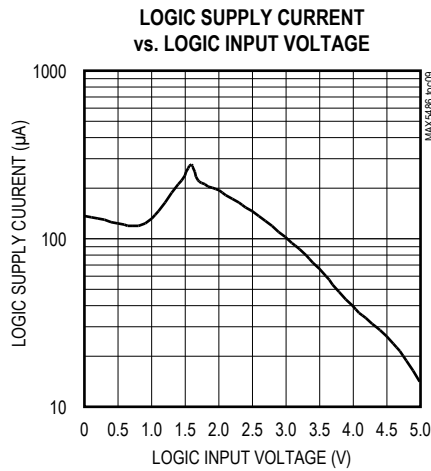
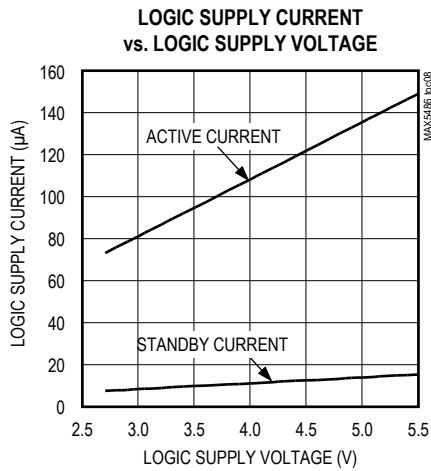
Typical Operating Characteristics

( $V_{DD} = +5.0V$ ,  $V_{SS} = GND = 0V$ ,  $V_{LOGIC} = +5.0V$ ,  $V_{H-} = V_{DD} - 0.15V$ ,  $V_{L-} = V_{DD}/2$ ,  $C_{BIASCAP} = 1\mu F$ .)



Typical Operating Characteristics (continued)

( $V_{DD} = +5.0V$ ,  $V_{SS} = GND = 0V$ ,  $V_{LOGIC} = +5.0V$ ,  $V_{H\_} = V_{DD} - 0.15V$ ,  $V_{L\_} = V_{DD}/2$ ,  $C_{BIASCAP} = 1\mu F$ .)



## Pin Description

PIN	NAME	FUNCTION
1	V <sub>LOGIC</sub>	Digital Logic Power Supply. Bypass V <sub>LOGIC</sub> to ground with a 0.1µF capacitor as close as possible to the device.
2	$\overline{\text{DN/BALR}}$	Active-Low Downward Volume/Balance Control. Press $\overline{\text{DN/BALR}}$ to decrease the volume in volume mode and move balance to the right in balance mode. $\overline{\text{DN/BALR}}$ is internally pulled high with a resistor to V <sub>LOGIC</sub> .
3	$\overline{\text{UP/BALL}}$	Active-Low Upward Volume/Balance Control. Press $\overline{\text{UP/BALL}}$ to increase the volume in volume mode and move balance to the left in balance mode. $\overline{\text{UP/BALL}}$ is internally pulled high with a resistor to V <sub>LOGIC</sub> .
4	$\overline{\text{MUTE}}$	Active-Low Mute Input. Pull $\overline{\text{MUTE}}$ low to toggle the wiper between the mute setting (see Table 1) and the current setting. $\overline{\text{MUTE}}$ is internally pulled up to V <sub>LOGIC</sub> with a resistor.
5	$\overline{\text{MODE}}$	Active-Low Volume/Balance Control Input. Each high-to-low transition on $\overline{\text{MODE}}$ toggles between the volume and balance modes. $\overline{\text{MODE}}$ is pulled high internally with a resistor to V <sub>LOGIC</sub> . On power-up, the MAX5486 is in volume control mode.
6	$\overline{\text{SHDN}}$	Active-Low Shutdown Input. Drive $\overline{\text{SHDN}}$ low to place the device in shutdown mode. In shutdown mode, the MAX5486 stores the last wiper settings. The wipers move to the L <sub>-</sub> end of the resistor string. Terminating the shutdown mode restores the wipers to the previous settings.
7	N.C.	Internally connected. Leave unconnected.
8	HR	Potentiometer R High Terminal
9	LR	Potentiometer R Low Terminal
10	WR	Potentiometer R Wiper Buffered Output
11	BIAS	Midbias Voltage Output. V <sub>BIAS</sub> = (V <sub>DD</sub> + V <sub>SS</sub> )/2; connect a 100pF capacitor from BIAS to V <sub>SS</sub> .
12	BIASCAP	Bias Generator Bypass. Connect a 1µF filter capacitor from BIASCAP to V <sub>SS</sub> .
13	V <sub>DD</sub>	Analog Power Supply. Bypass V <sub>DD</sub> to ground with a 0.1µF capacitor as close as possible to the device.
14	V <sub>SS</sub>	Negative Power Supply. Bypass V <sub>SS</sub> to ground with a 0.1µF capacitor as close as possible to the device. Connect to GND for single-supply operation.
15	WL	Potentiometer L Wiper Buffered Output
16	LL	Potentiometer L Low Terminal
17	HL	Potentiometer L High Terminal
18–22	LEDIND0– LEDIND4	LED Indicator Open-Drain Output 0–LED Indicator Open-Drain Output 4. Connect a 1MΩ resistor from LEDIND4 to V <sub>LOGIC</sub> to enable these LED inductor drivers. LEDIND0–LEDIND4 form a bar graph indication of the current volume or balance. In volume mode, all LEDs off indicate mute and all LEDs on indicate maximum volume. In balanced mode, LED2 on indicates centered or balanced. Connect LEDIND0–LEDIND4 to GND when LED indicator drivers are not used.
23	$\overline{\text{MODEIND}}$	Active-Low Volume-Control/Balance-Control Mode-Indicator Open-Drain Output. Connect to an LED through a resistor to V <sub>LOGIC</sub> . When the LED is on, the MAX5486 is in balance-control mode. When the LED is off, the MAX5486 is in volume-control mode.
24	GND	Ground

### Detailed Description

The MAX5486 dual 40kΩ logarithmic taper digital volume control features a debounced pushbutton interface that controls volume and balance in audio applications. Each potentiometer has 32 log-spaced tap points with a buffered wiper output and replaces mechanical potentiometers.

### Mode Control (MODE)

The MAX5486  $\overline{\text{MODE}}$  input toggles between volume and balance modes. Each time  $\overline{\text{MODE}}$  is forced low, the device switches between volume and balance modes. For example, driving  $\overline{\text{MODE}}$  low once while in volume-control mode switches the MAX5486 to balance mode. Driving  $\overline{\text{MODE}}$  low again switches the MAX5486 back to volume mode.  $\overline{\text{MODE}}$  is internally pulled high with a resistor to  $V_{\text{LOGIC}}$ . The MAX5486 powers up in volume-control mode. Leave unconnected or connect to  $V_{\text{LOGIC}}$  if balance mode is not required.

### Up-and-Down Interface

The MAX5486 interfaces with momentary contact SPST switches. All switch inputs are internally debounced and pulled up to  $V_{\text{LOGIC}}$  through resistors. The wiper setting advances once per button press up to 250ms. Maxim’s SmartWiper control circuitry allows the wiper to advance at a 4Hz rate after holding the button for approximately 250ms. After 500ms, the wiper moves at an 8Hz rate. After 1s, the rate increases to 11Hz (see Table 2). The SmartWiper control eliminates the need for a microcomputer to increase the wiper transition rate.

The MAX5486  $\overline{\text{MODE}}$  input toggles the part between volume and balance-control modes. The  $\overline{\text{UP}}/\overline{\text{BALL}}$  and  $\overline{\text{DN}}/\overline{\text{BALR}}$  inputs control the wiper according to the selected mode.  $\overline{\text{MODE}}$  is internally pulled high with a resistor to  $V_{\text{LOGIC}}$ .

### Volume Control

In volume-control mode, the MAX5486’s wipers move simultaneously, maintaining the balance separation between each wiper (Figure 2a).

When either wiper reaches the maximum tap position (position closest to H<sub>-</sub>), further commands to increase the volume are ignored. Balance separation is maintained in the maximum volume configuration (Figure 2b).

When either wiper reaches the minimum tap position (position closest to L<sub>-</sub>), further commands to decrease the volume adjust the other wiper until it also reaches the minimum tap position (Figure 2c). Increasing the volume from this minimum position restores the original balance separation of the wipers (Figure 2d).

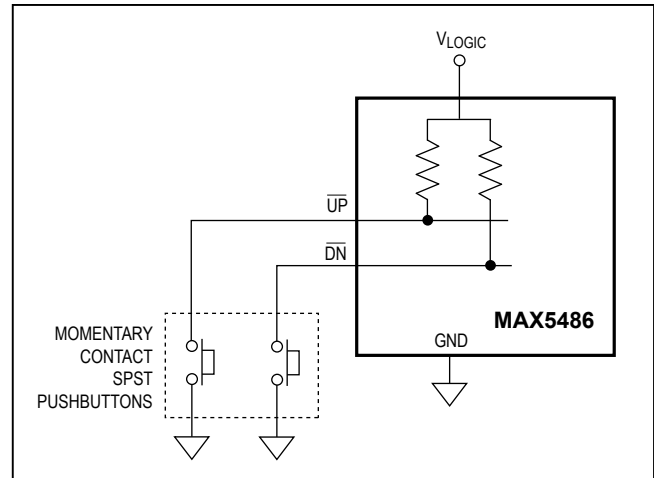


Figure 1. Pushbutton Interface

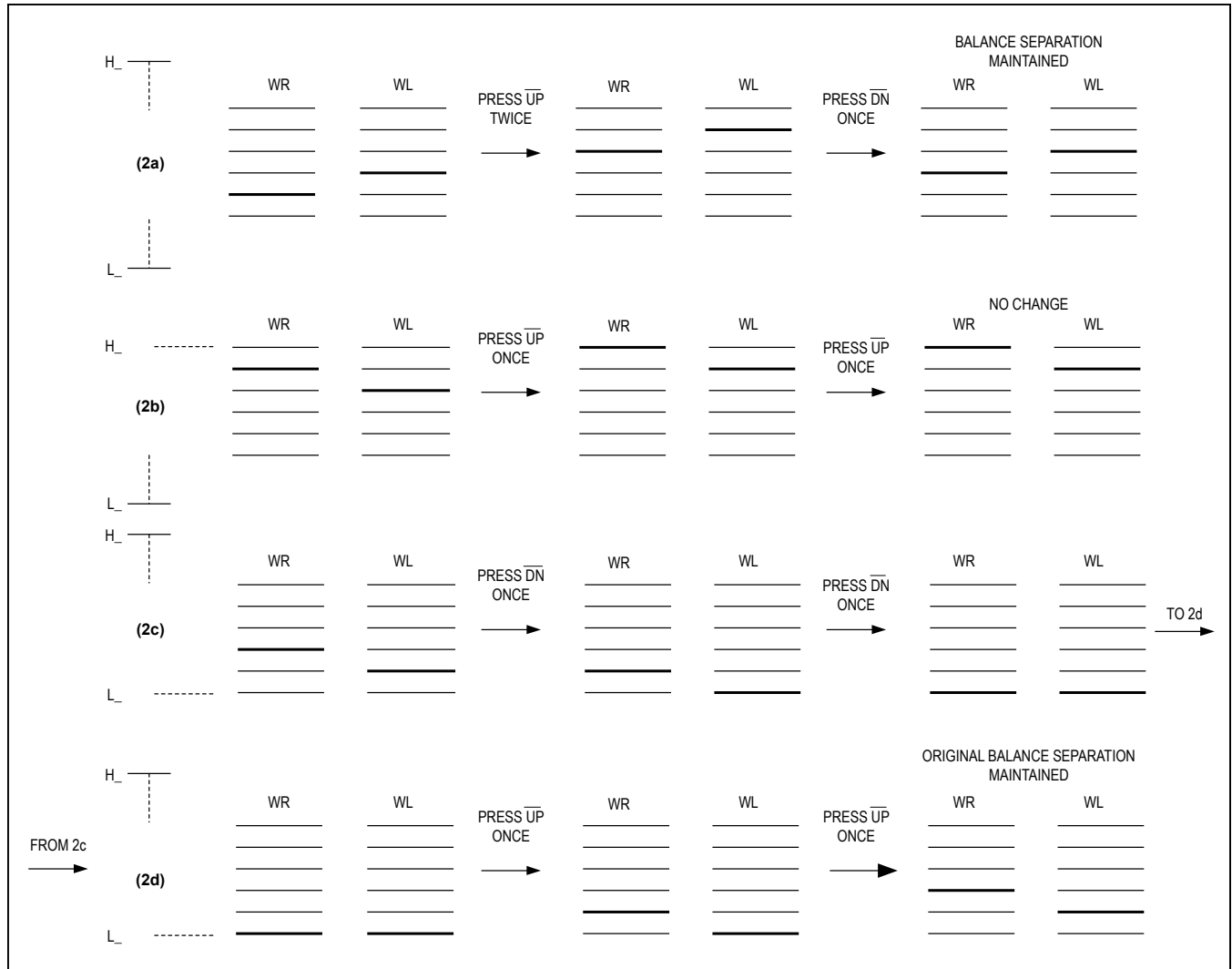
### Table 1. Wiper Position and Attenuation

POSITION	ATTENUATION (dB)
0	0
1	2
2	4
3	6
4	8
...	...
30	60
31	62
32 (mute)	> 90

### Table 2. Wiper Action vs. Pushbutton Contact Duration

CONTACT DURATION	WIPER ACTION
$t \leq 16\text{ms}$	No motion.
$16\text{ms} < t \leq 250\text{ms}$	Wiper changes position once.
$250\text{ms} < t \leq 500\text{ms}$	SmartWiper begins. Wiper changes position at a rate of 4Hz.
$500\text{ms} < t \leq 1000\text{ms}$	Wiper changes position at a rate of 8Hz.
$t > 1000\text{ms}$	Wiper changes position at a rate of 11Hz.





Figures 2a–2d. Volume-Control Operation

When both wipers are in the tap 31 position (-62dB attenuation), further commands to  $\overline{\text{DN/BALR}}$  place the wipers in the mute position (see Table 1).  $\overline{\text{UP/BALL}}$  or  $\overline{\text{MUTE}}$  pulses return the wipers to tap 31.

### Balance Control

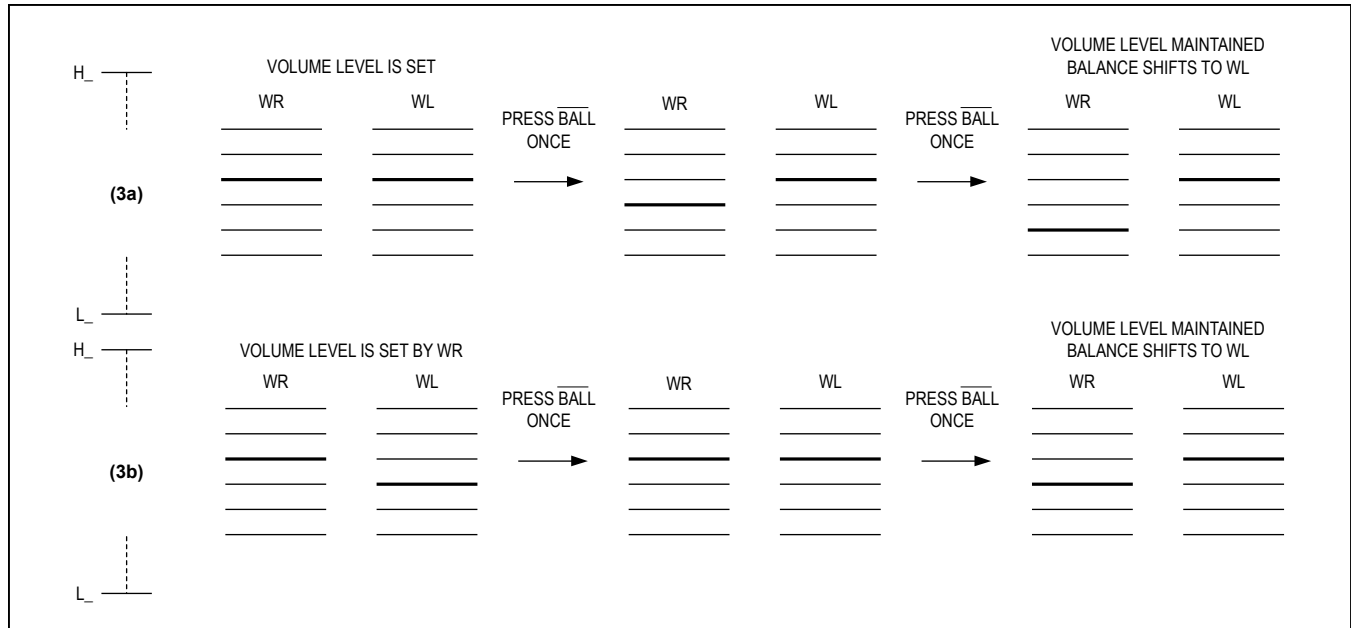
In balance-control mode, the MAX5486 adjusts the balance between the right and left channels while maintaining the set volume. For example, if the volume of the right channel equals the volume of the left channel, forcing the balance towards the left channel increases the attenuation of the right channel (Figure 3a). If the left channel is at a higher attenuation than the right channel, adjusting the balance to the left channel moves the left channel's wiper

up to the same wiper position as the right channel before it was attenuated (Figure 3b).

### Click-and-Pop Suppression

The click-and-pop suppression feature reduces the audible noise (clicks and pops) that results from wiper transitions. The MAX5486 minimizes this noise by allowing the wiper to change position only when  $V_H = V_L$  (zero crossing) or after the zero crossing timeout (126ms). Each wiper has its own suppression and timeout circuitry. The MAX5486 changes wiper position when  $V_H = V_L$ , or after 32ms, whichever occurs first (see Figures 4a and 4b).

The suppression circuitry monitors left and right channels separately. In volume-control mode, when the first wiper



Figures 3a and 3b. Balance-Control Operation

changes position, the second wiper has 126ms to change or it changes automatically.

**Power-On Reset**

The power-on comparators monitor ( $V_{DD} - V_{SS}$ ) and ( $V_{LOGIC} - GND$ ). A power-on reset is initiated when either of the supplies is brought back to the normal operating voltage. The power-on reset feature sets both wipers to -12dB. The wipers initially wake up in mute mode (-90dB) and move to the -12dB position when  $V_H = V_L$  to eliminate clicks and pops during power-up. With DC inputs at  $V_H$  and  $V_L$ , the wipers move after exceeding the timeout period. A power-on reset places the MAX5486 in volume-control mode.

**Shutdown ( $\overline{SHDN}$ )**

Upon entering shutdown, the MAX5486 stores the last wiper settings. The wipers move to the L<sub>L</sub> end of the resistor string when  $V_H = V_L$  to eliminate clicks and pops during shutdown. With DC inputs at  $V_H$  and  $V_L$ , the wipers move after exceeding the timeout period. Exiting shutdown restores the wipers to their previous settings. Shutdown also turns off all the LED indicators to save power.

**Mute Function ( $\overline{MUTE}$ )**

The MAX5486 features a mute function input,  $\overline{MUTE}$ . Successive low pulses on  $\overline{MUTE}$  toggle its setting. Activating the mute function forces both wipers to maxi-

mum attenuation (-90dB typ). Deactivating the mute function returns the wipers to their previous settings.  $\overline{MUTE}$  is internally pulled high with a resistor to  $V_{LOGIC}$ . When both wipers are in the tap 31 position (-62dB attenuation) further commands to lower the volume place the wipers in the mute position (see Table 1).

**Mode Indicator ( $\overline{MODEIND}$ )**

The open-drain  $\overline{MODEIND}$  indicates volume-control mode or balance-control mode for the MAX5486. Connect  $\overline{MODEIND}$  to an LED with a series resistor to  $V_{LOGIC}$ . When the LED is on, the MAX5486 is in balance-control mode. When the LED is off, the MAX5486 is in volume-control mode. See the *Mode Control ( $\overline{MODE}$ )* section for more detail on switching between modes.

**Level Indicator LEDs**

The MAX5486 includes five indicator LED drivers to display the current wiper settings in either volume or balance mode. The LED indicators are enabled by connecting a 1M $\Omega$  resistor between LEDIND4 and  $V_{LOGIC}$ . Connect the LEDIND<sub>n</sub> outputs to the LEDs and to  $V_{LOGIC}$  through a series resistor as shown in the *Typical Operating Circuit*. Connect LEDIND<sub>n</sub> outputs to GND when LED indicator drivers are not used.

In volume-control mode, all LEDs are off when the wipers reach the highest attenuation levels (mute). All LEDs are on at the lowest attenuation levels (0dB).

**Table 3. LED Settings in Volume Mode**

VOLUME POSITION	WIPER ACTION				
	LED0	LED1	LED2	LED3	LED4
0dB to -8dB	1	1	1	1	1
-10dB to -18dB	1	1	1	1	0
-20dB to -28dB	1	1	1	0	0
-30dB to -38dB	1	1	0	0	0
-40dB to -52dB	1	0	0	0	0
-54dB to mute (-90dB)	0	0	0	0	0

Table 3 shows the LED display as the wipers transition through various attenuation levels.

A PWM circuit interpolates the high-resolution 32 steps between the five LEDs over the volume range from 0dB to -54dB. This feature provides visible indication for the attenuation levels from 0dB to -54dB. For example, LED4 brightness level decreases progressively with each -2dB step from 0dB to -8dB. PWM is disabled in the range -56dB to mute.

In balance-control mode, only one LED is on at a time to indicate the current balance setting. Figure 5 shows the LEDs display for the current balance setting. When LED2 is on, the display indicates that the channels are centered or balanced at a set volume level. When LED4 turns on, the balance shifts completely toward the right channel and the left channel becomes fully attenuated.

### Multiple Button Pushes

The MAX5486 does not respond to simultaneous button pushes. Additionally, a 16ms blocking period affects all other inputs when releasing any input that was forced low.

The MAX5486 does not respond to any logic input until the blocking period ends. If multiple-control buttons are pressed, all wiper-control connections must be released before the device responds to further commands.

### Applications Information

The *Typical Operating Circuit* shows a typical volume/balance application circuit using the MAX5486 in a single-supply configuration. The internally generated BIAS voltage eliminates the need for external op amps, and the wipers have internal low-power buffers for low distortion. Connect the  $W_{-}$  outputs of the MAX5486 to the left and right inputs of a stereo audio amplifier, such as the MAX9761. The pushbutton potentiometers attenuate the input signals. Use the  $\overline{\text{MODE}}$  input to switch between volume-control and balance-control modes.

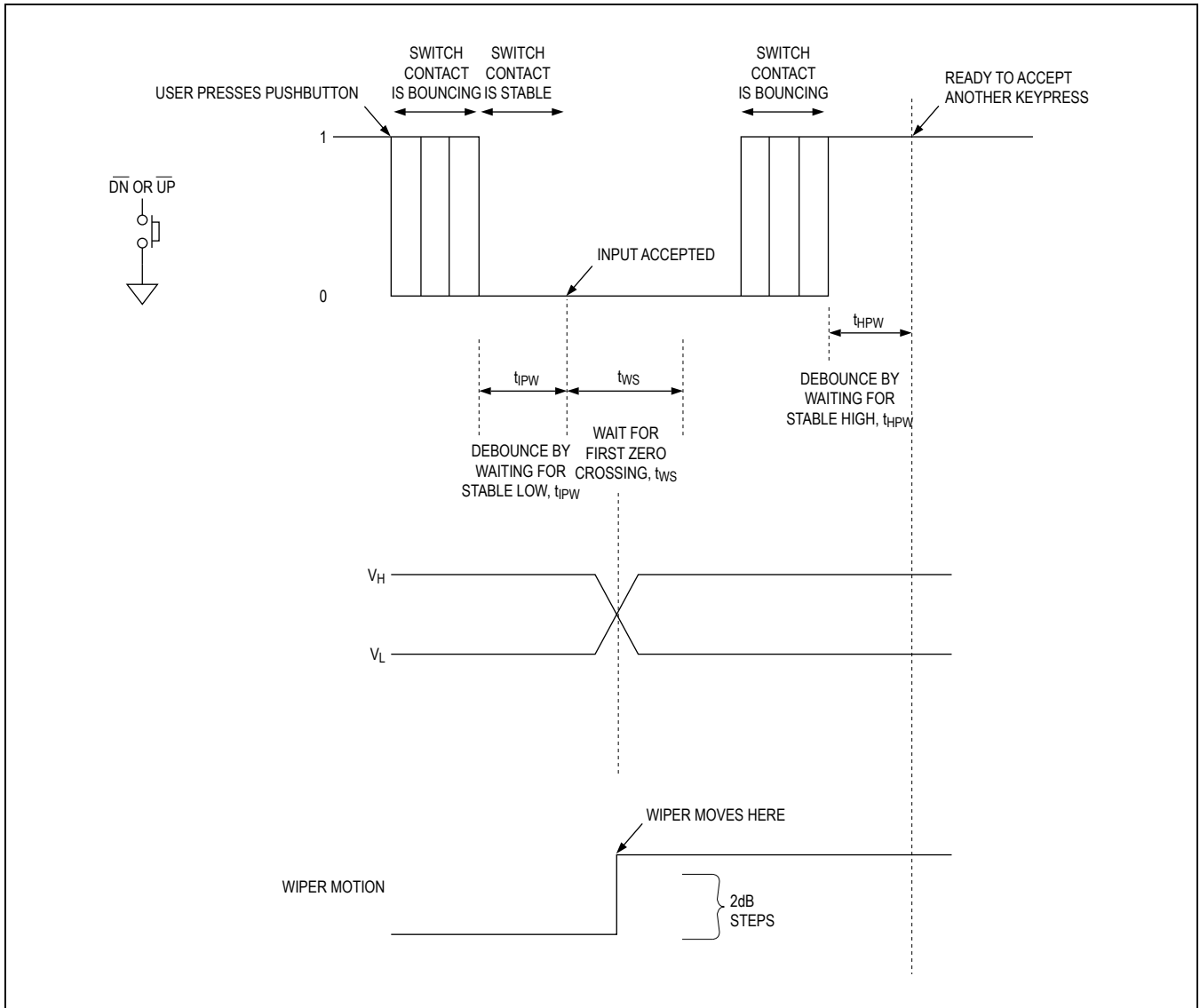


Figure 4a. Wiper Transition Timing Diagram—Suppression Circuitry Active

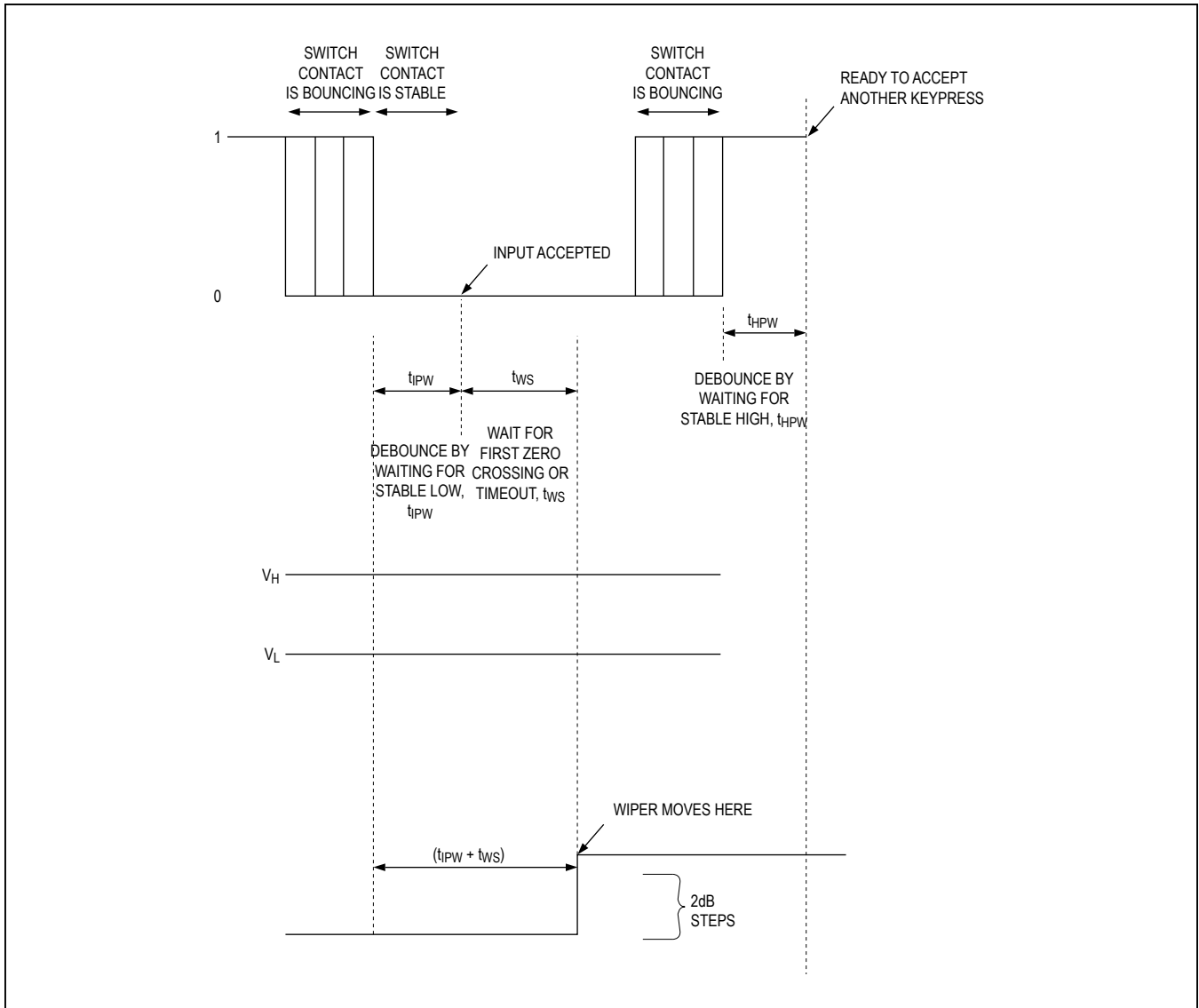


Figure 4a. Wiper Transition Timing Diagram—Suppression Circuitry Active

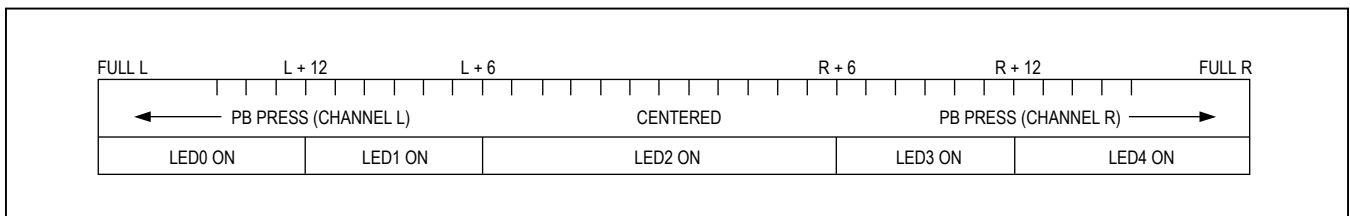
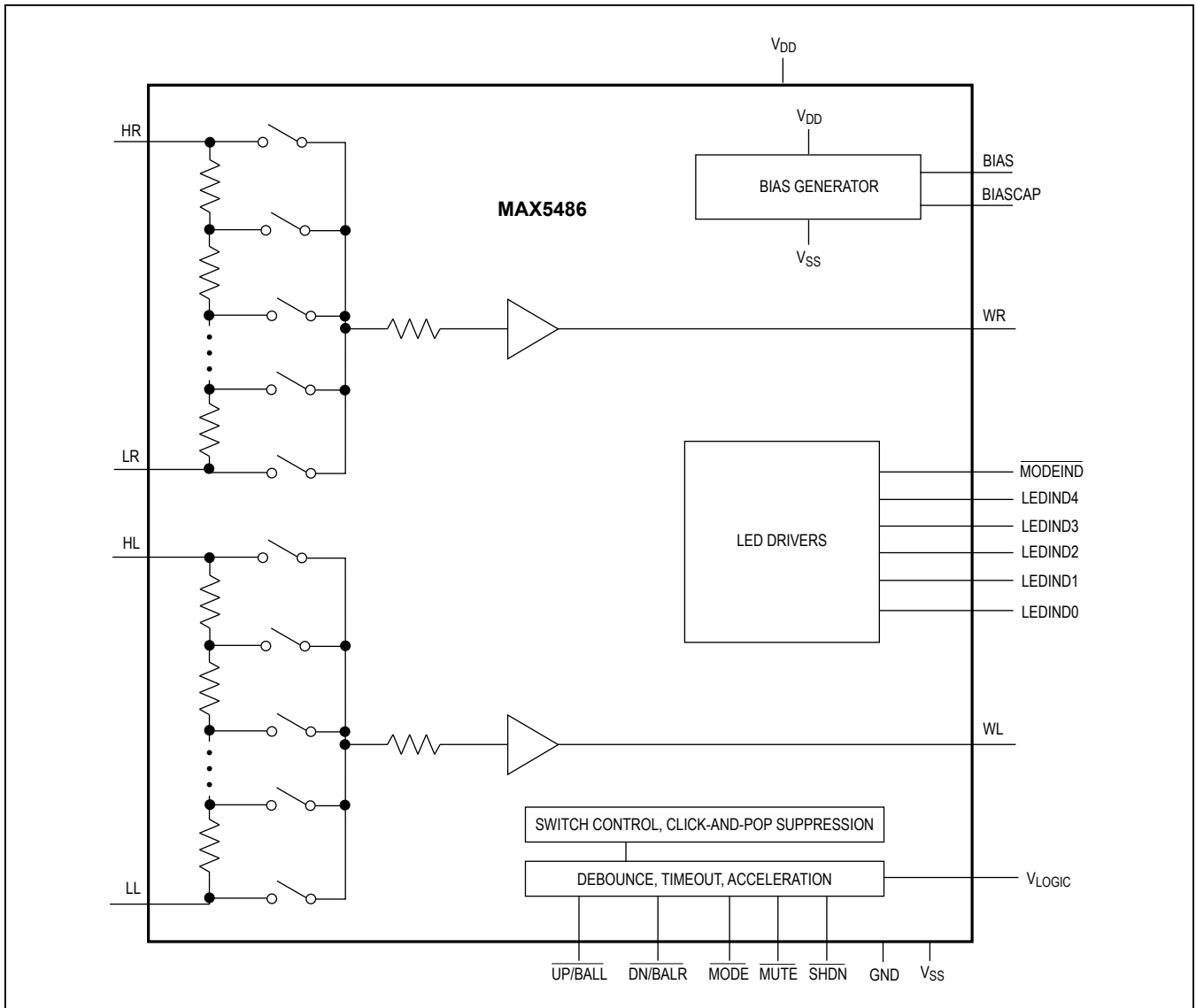
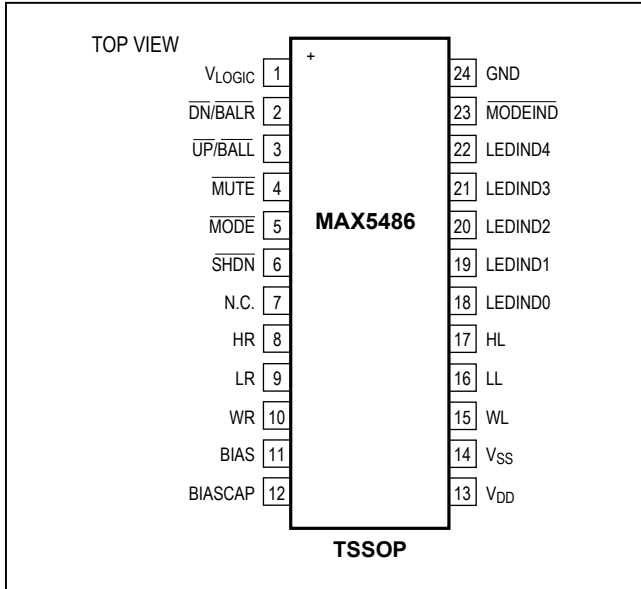


Figure 5. LED Settings in Balance Mode

Functional Diagram



Functional Diagram



Chip Information

PROCESS: BiCMOS

Package Information

For the latest package outline information and land patterns (footprints), go to [www.maximintegrated.com/packages](http://www.maximintegrated.com/packages). Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

PACKAGE TYPE	PACKAGE CODE	OUTLINE NO.	LAND PATTERN NO.
24 TSSOP	U24+1	21-0066	90-0118

## Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	11/06	Initial Release	—
1	4/14	Updated <i>Applications</i>	1

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