MAXIM

128-Tap, Nonvolatile, Linear-Taper Digital Potentiometer in 2mm x 2mm µDFN Package

General Description

The MAX5128 nonvolatile, single, linear-taper, digital potentiometer performs the function of a mechanical potentiometer, but replaces the mechanics with a simple 2-wire digital interface. The MAX5128 performs the same function as a discrete potentiometer or variable resistor and features 128 taps and 22kΩ end-to-end resistance. The MAX5128 also features an ultra-small, 2mm x 2mm µDFN package and low 0.5µA (typ) standby supply current, making this device ideal for portable applications. The MAX5128 operates from a +2.7V to +5.25V power supply. An integrated nonvolatile memory recalls the programmed wiper position of the digital potentiometer. A simple 2-wire up/down interface programs the wiper position. The digital potentiometer provides a low 5ppm/°C ratiometric temperature coefficient and is specified over the extended -40°C to +85°C temperature range.

Applications

V_{COM} Adjustment for LCD Panels

Backlight Adjustment

LED Bias Adjustment

Power-Supply Modules

Fiber-Module Bias Setting

Bias Setting for Radios

Portable Consumer Electronics

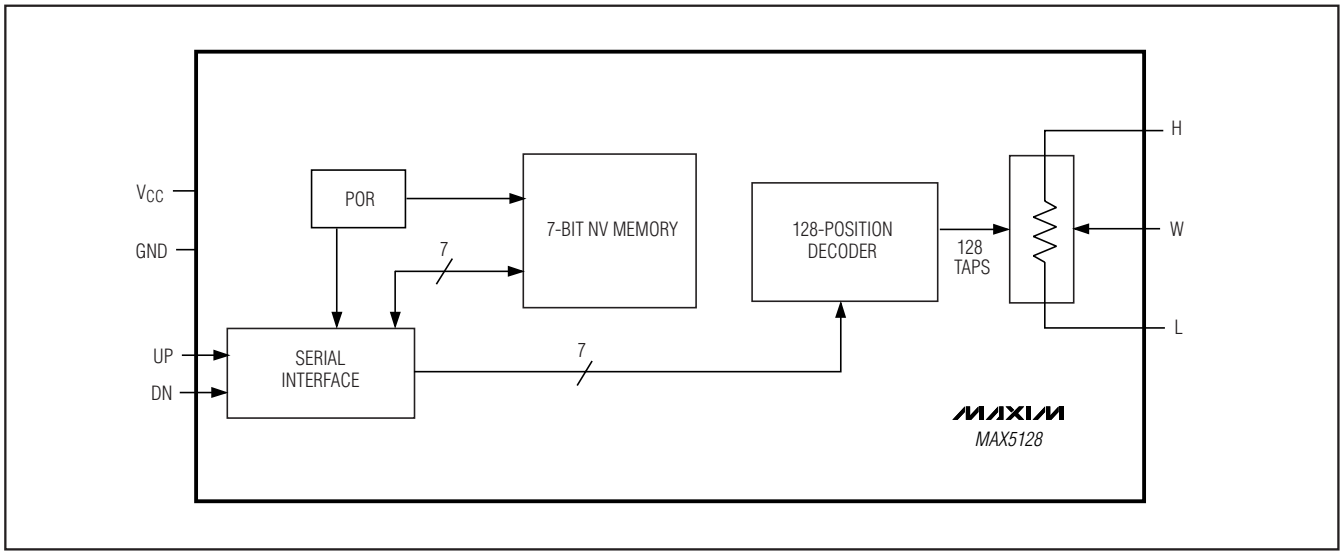
Features

- **Ultra-Small, 2mm x 2mm, 8-Pin µDFN Package**
- **Power-On Recall of Wiper Position from Nonvolatile Memory**
- **22kΩ End-to-End Resistance**
- **128 Tap Positions**
- **5ppm/°C Ratiometric Temperature Coefficient**
- **1.5µA (max) Standby Supply Current**
- **+2.7V to +5.25V Single Supply Operation**
- **80,000 Wiper Store Cycles**
- **50-Year Wiper Data Retention**

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	TOP MARK	PKG CODE
MAX5128ELA	-40°C to +85°C	8 µDFN	AAF	L822-1

Functional Diagram



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ABSOLUTE MAXIMUM RATINGS

V_{CC} to GND .....-0.3V to +6.0V
UP and DN to GND .....-0.3V to (V_{CC} + 0.3V)
H, L, and W to GND.....-0.3V to (V_{CC} + 0.3V)
Maximum Continuous Current into H, L, and W .....±0.5mA
Maximum Continuous Current into All Other Pins .....±50mA
Continuous Power Dissipation (T_A = +70°C)
8-Pin µDFN (derate 4.7mW/°C above +70°C) 376.5mW
Operating Temperature Range .....-40°C to +85°C
Junction Temperature.....+150°C
Storage Temperature Range .....-60°C to +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_{CC} = +2.7V to +5.25V, H = V_{CC}, L = GND, T_A = -40°C to +85°C. Typical values are at V_{CC} = +5.0V, T_A = +25°C, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
DC PERFORMANCE (Voltage-Divider Mode)						
Resolution	N		7			Bits
Integral Nonlinearity	INL	(Note 2)			±1.0	LSB
Differential Nonlinearity	DNL	(Note 2)			±1.0	LSB
End-to-End Resistance Temperature Coefficient	TC_R			50		ppm/°C
Ratiometric Resistance Temperature Coefficient				5		ppm/°C
Full-Scale Error	FSE		-3		0	LSB
Zero-Scale Error	ZSE		0		+2	LSB
DC PERFORMANCE (Variable-Resistor Mode)						
Integral Nonlinearity	INL	(Note 3)			±1.75	LSB
Differential Nonlinearity	DNL	(Note 3)			±1	LSB
DC PERFORMANCE (Resistor Characteristics)						
Wiper Resistance	R_W	(Note 4)		0.6	0.8	kΩ
Wiper Capacitance	C_W			20		pF
End-to-End Resistance	R_{HL}		16	22	27	kΩ
DIGITAL INPUTS (UP, DN)						
Input-High Voltage (Note 5)	V_{IH}	3.4V ≤ V_{CC} ≤ 5.25V	2.4			V
		2.7V ≤ V_{CC} < 3.4V	0.7 x V_{CC}			
Input-Low Voltage	V_{IL}	(Note 5)			0.8	V
Input Leakage Current	I_{IN}				±1	µA
Input Capacitance	C_{IN}			5		pF
DYNAMIC CHARACTERISTICS						
Wiper -3dB Bandwidth	f_{3dB}	(Note 6)		400		kHz
THD Plus Noise	THD+N	V_H = 0.3V_{RMS}, f = 1kHz, wiper set to midscale		0.02		%

ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = +2.7V to +5.25V, H = V_{CC}, L = GND, T_A = -40°C to +85°C. Typical values are at V_{CC} = +5.0V, T_A = +25°C, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
NONVOLATILE MEMORY RELIABILITY						
Data Retention		T_A = +85°C		50		Years
Endurance		T_A = +25°C		80,000		Stores
		T_A = +85°C		50,000		
POWER SUPPLY						
Supply Voltage	V_{CC}		2.70		5.25	V
Average Programming Current	I_{PG}	During nonvolatile write only; digital inputs = V_{CC} or GND		220	400	µA
Peak Programming Current	I_{PK}	During nonvolatile write only; digital inputs = V_{CC} or GND		4		mA
Standby Current	I_{CC}	Digital inputs = V_{CC} or GND, T_A = +25°C		0.5	1.5	µA

TIMING CHARACTERISTICS

(V_{CC} = +2.7V to +5.25V, H = V_{CC}, L = GND, T_A = -40°C to +85°C. Typical values are at V_{CC} = +5.0V, T_A = +25°C, unless otherwise noted. See Figures 1, 2, 3, and 4).

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
ANALOG SECTION						
Wiper Settling Time	t_S	(Note 7)		500		ns
DIGITAL SECTION						
UP or DN Pulse-Width High	t_{PWH}		80			ns
UP or DN Pulse-Width Low	t_{PWL}		80			ns
UP or DN Glitch Immunity	t_{IMMU}		20			ns
UP Fall to DN Rise Setup or DN Fall to UP Rise Setup	t_{MS1}		80			ns
Before Entering NVM-Write Mode, UP Fall to UP Rise	t_{MS2}		80			ns
UP Rise to DN Rise Setup when Entering NVM-Write	t_{WS}		80			ns
UP Fall to DN Fall Hold or DN Fall to UP Fall Hold during NVM-Write	t_{WH}		0			ns

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TIMING CHARACTERISTICS

(V_{CC} = +2.7V to +5.25V, H = V_{CC}, L = GND, T_A = -40°C to +85°C. Typical values are at V_{CC} = +5.0V, T_A = +25°C, unless otherwise noted. See Figures 1, 2, 3, and 4).

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
NVM-Write Mode Pulse-Width High	t_{WP}		80			ns
Write NV Register Busy Time	t_{BUSY}				14	ms
Power-Up Settling Time	t_{ACC}	(Note 8)		2		µs

Note 1: All devices are production tested at T_A = +25°C and are guaranteed by design for T_A = -40°C to +85°C.

Note 2: The DNL and INL are measured with the potentiometer configured as a voltage-divider with H = V_{CC} and L = GND. The wiper terminal is unloaded and measured with a high input-impedance voltmeter.

Note 3: The DNL and INL are measured with the potentiometer configured as a variable resistor. H is unconnected and L = GND. For the +5V condition, the wiper terminal is driven with a source current of 200µA and for the 2.7V condition, the wiper terminal is driven with a source current of 100µA.

Note 4: The wiper resistance is measured using the source currents given in Note 3.

Note 5: The device draws higher supply current when the digital inputs are driven with voltages between (V_{CC} - 0.5V) and (GND + 0.5V). See Supply Current vs. Digital Input Voltage in the *Typical Operating Characteristics*.

Note 6: Wiper at midscale with a 10pF load, L = GND, an AC source is applied to H, and the output is measured as 3dB lower than the DC W/H value in dB.

Note 7: Wiper-settling time is the worst-case 0% to 50% rise-time measured between consecutive wiper positions. H = V_{CC}, L = GND, and the wiper terminal is unloaded and measured with a 10pF oscilloscope probe. See the Tap-to-Tap Switching Transient in the *Typical Operating Characteristics* section.

Note 8: Power-up settling time is measured from the time V_{CC} = 2.7V to the wiper settling to 1 LSB of the final value.