19-3053; Rev 0; 10/03

EVALUATION KIT AVAILABLE

3.5- and 4.5-Digit, Single-Chip ADCs with LCD Drivers

General Description

The MAX1491/MAX1493/MAX1495 low-power, 3.5- and 4.5-digit, analog-to-digital converters (ADCs) with integrated liquid crystal display (LCD) drivers operate from a single 2.7V to 5.25V power supply. They include an internal reference, a high-accuracy on-chip oscillator, and a triplexed LCD driver. An internal charge pump generates the negative supply needed to power the integrated input buffer for single supply operation. The ADC is configurable for either a ±2V or ±200mV input range and it outputs its conversion results to an LCD. The MAX1491 is a 3.5-digit (±1,999 count) device, and the MAX1493/MAX1495 are 4.5-digit (±19,999 count) devices.

The MAX1491/MAX1493/MAX1495 do not require external-precision integrating or auto-zero capacitors, crystal oscillators, charge pumps or other circuitry required with dual slope ADCs (commonly used in panel meter circuits). These devices also feature on-chip buffers for the differential signal and reference inputs, allowing direct interface with high-impedance signal sources. In addition, the MAX1491/MAX1493/MAX1495 use continuous internal offset calibration, and offer >100dB rejection of 50Hz and 60Hz line noise. The MAX1493/MAX1495 perform enhanced offset calibration at power-up. The MAX1495 also performs enhanced calibration on demand. Other features include data hold and peak hold, and a user programmable low-battery monitor.

The MAX1493/MAX1495 come in a 32-pin 7mm × 7mm TQFP package, and the MAX1491 comes in 28-pin SSOP and 28-pin DIP packages. All devices in this family operate over the 0°C to +70°C commercial temperature range.

Applications

Digital Panel Meters

Hand-Held Meters

Digital Voltmeters

Digital Multimeters

Ordering Information

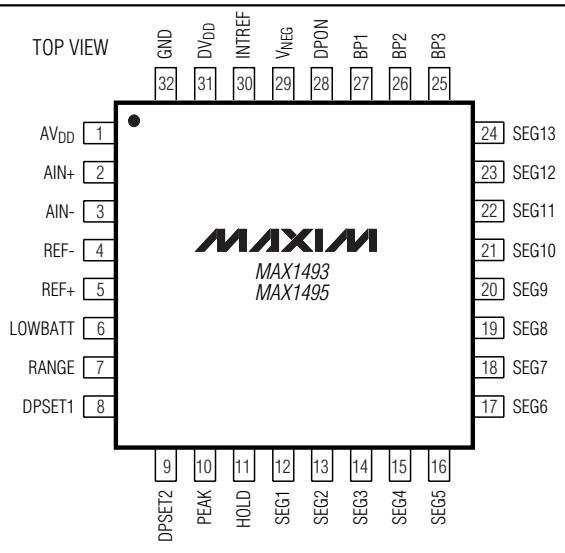
PART	TEMP RANGE	PIN-PACKAGE	RESOLUTION (DIGITS)
MAX1491CAI*	0°C to +70°C	28 SSOP	3.5
MAX1491CNI	0°C to +70°C	28 DIP	3.5
MAX1493CCJ	0°C to +70°C	32 TQFP	4.5
MAX1495CCJ*	0°C to +70°C	32 TQFP	4.5

**Future product—contact factory for availability.*

Features

- **High Resolution**
  - **MAX1495: 4.5 Digits (±19,999 Count)**
  - **MAX1493: 4.5 Digits (±19,999 Count)**
  - **MAX1491: 3.5 Digits (±1999 Count)**
- **Sigma-Delta ADC Architecture**
  - **No Integrating Capacitors Required**
  - **No Autozeroing Capacitors Required**
  - **>100dB of Simultaneous 50Hz and 60Hz Rejection**
- **Operate from a Single 2.7V or 5.25V Supply**
- **Selectable Input Range of ±200mV or ±2V**
- **Selectable Voltage Reference: Internal 2.048V or External**
- **Internal High-Accuracy Oscillator Needs No External Components**
- **Automatic Offset Calibration**
- **Low Power: Maximum 980µA Operating Current**
- **Small 32-Pin 7mm × 7mm TQFP Package (4.5 Digits), 28-Pin SSOP Package (3.5 Digits), and 28-Pin DIP Package (3.5 Digits)**
- **Triplexed LCD Driver**
- **Evaluation Kit Available (Order MAX1494EVKIT)**

Pin Configurations



TQFP

Pin Configurations continued at end of data sheet.

3.5- and 4.5-Digit, Single-Chip ADCs with LCD Drivers

ABSOLUTE MAXIMUM RATINGS

AV_{DD} to GND .....-0.3V to +6V
DV_{DD} to GND .....-0.3V to +6V
AIN+, AIN- to GND .....V_{NEG} to + (AV_{DD} + 0.3V)
REF+, REF- to GND .....V_{NEG} to + (AV_{DD} + 0.3V)
LOWBATT to GND .....-0.3V to (AV_{DD} + 0.3V)
INTREF, RANGE, DPSET1, DPSET2, PEAK, HOLD to GND .....-0.3V to (DV_{DD} + 0.3V)
DPON to GND .....-0.3V to (DV_{DD} + 0.3V)
V_{NEG} to GND .....-2.6V to (AV_{DD} + 0.3V)
Maximum Current into Any Pin 50mA

Continuous Power Dissipation (T_A = +70°C)
32-Pin TQFP (derate 20.7mW/°C above +70°C).....1652.9mW
28-Pin SSOP (derate 9.5mW/°C above +70°C) 762mW
28-Pin DIP (derate 14.3mW/°C above +70°C).....1142.9mW
Operating Temperature Range.....0°C to +70°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

(AV_{DD} = DV_{DD} = +2.7V to +5.25V, GND = 0, V_{REF+} - V_{REF-} = 2.048V (external reference), C_{NEG}= 0.1µF. All specifications are T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at +25°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
DC ACCURACY							
Noise-Free Resolution		MAX1493/MAX1495		-19,999		+19,999	Count
		MAX1491		-1999		+1999	
Integral Nonlinearity (Note 1)	INL	2.000V range			±1		Count
		200mV range			±1		
Range Change Accuracy		(V_{AIN+} - V_{AIN-} = 0.100V) on 200mV range / (V_{AIN+} - V_{AIN-} = 0.100V) on 2.0V range			10:1		Ratio
Rollover Error		V_{AIN+} - V_{AIN-} = full scale, V_{AIN-} - V_{AIN+} = full scale			±1.0		Count
Output Noise					10		μV_{P-P}
Offset Error (Zero Input Reading)	Offset	V_{IN} = 0 (Note 2)		-0		+0	Reading
Gain Error		(Note 3)		-0.5		+0.5	%FSR
Offset Drift (Zero Reading Drift)		V_{IN} = 0			0.1		µV/°C
Gain Drift					±1		ppm/°C
INPUT CONVERSION RATE							
Conversion Rate					5		Hz
ANALOG INPUTS (AIN+, AIN-) (bypass to GND with 0.1µF or greater capacitors)							
AIN Input Voltage Range		Differential (Note 4)	RANGE = GND	-2.0		+2.0	V
			RANGE = DV_{DD}	-0.2		+0.2	
		Absolute GND referenced		-2.2V		+2.2V	
Normal Mode 50Hz and 60Hz Rejection (Simultaneously)		50Hz and 60Hz ±2%			100		dB
Common-Mode 50Hz and 60Hz Rejection (Simultaneously)	CMR	For 50Hz ±2% and 60Hz ±2%, R_{SOURCE} < 10kΩ			150		dB
Common-Mode Rejection	CMR	At DC			100		dB
Input Leakage Current		T_A = +25°C			10		nA
Input Capacitance					10		pF
Dynamic Input Current		(Note 5)		-20		+20	nA

ELECTRICAL CHARACTERISTICS (continued)

(AV_{DD} = DV_{DD} = +2.7V to +5.25V, GND = 0, V_{REF+} - V_{REF-} = 2.048V (external reference), C_{NEG}= 0.1µF. All specifications are T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at +25°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
LOW-BATTERY VOLTAGE MONITOR (LOWBATT)						
LOWBATT Trip Threshold				2.048		V
LOWBATT Leakage Current				10		pA
Hysteresis				20		mV
INTERNAL REFERENCE (REF- = GND, INTREF = DV_{DD}, bypass REF+ to GND with 4.7µF capacitors)						
REF Output Voltage	V_{REF}	AV_{DD} = 5V, T_A = +25°C	2.007	2.048	2.089	V
REF Output Short-Circuit Current		T_A = +25°C		1		mA
REF Output Temperature Coefficient	TC_{VREF}	AV_{DD} = 5V		40		ppm/°C
Load Regulation		I_{SOURCE} = 0µA to 300µA, I_{SINK} = 0µA to 30µA, T_A = +25°C (Note 6)		6		mV/µA
Line Regulation				50		µV/V
Noise Voltage		0.1Hz to 10Hz		25		µVp-p
		10Hz to 10kHz		400		
EXTERNAL REFERENCE (INTREF = GND, bypass REF+ and REF- to GND with 0.1µF or greater capacitors)						
REF Input Voltage		Differential (V_{REF+} - V_{REF-})		2.048		V
		Absolute GND referenced	-2.2		+2.2	
Normal-Mode 50Hz and 60Hz Rejection (Simultaneously)		50Hz and 60Hz ±2%		100		dB
Common-Mode 50Hz and 60Hz Rejection (Simultaneously)	CMR	For 50Hz ±2% and 60Hz ±2%, R_{SOURCE} < 10kΩ		150		dB
Common-Mode Rejection	CMR	At DC		100		dB
Input Leakage Current		T_A = +25°C		10		nA
Input Capacitance				10		pF
Dynamic Input Current		(Note 5)	-20		+20	nA
CHARGE PUMP						
Output Voltage	V_{NEG}		-2.6	-2.42	-2.3	V
DIGITAL INPUTS (INTREF, RANGE, PEAK, HOLD, DPSET1, DPSET2, DPON)						
Input Current	I_{IN}	V_{IN} = 0 or DV_{DD}	-10		+10	µA
Input Low Voltage	V_{INL}				0.3 x DV_{DD}	V
Input High Voltage	V_{INH}		0.7 x DV_{DD}			V
Input Hysteresis	V_{HYS}	DV_{DD} = 3.0V		200		mV

ELECTRICAL CHARACTERISTICS (continued)

(AV_{DD} = DV_{DD} = +2.7V to +5.25V, GND = 0, V_{REF+} - V_{REF-} = 2.048V (external reference), C_{NEG}= 0.1µF. All specifications are T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at +25°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
POWER SUPPLY						
AV_{DD} Voltage	AV_{DD}		2.70		5.25	V
DV_{DD} Voltage	DV_{DD}		2.70		5.25	V
Power-Supply Rejection AV_{DD}	$PSRR_A$	(Note 7)		80		dB
Power-Supply Rejection DV_{DD}	$PSRR_D$	(Note 7)		100		dB
AV_{DD} Current	I_{AVDD}	(Note 8)			660	µA
DV_{DD} Current	I_{DVDD}	DV_{DD} = 5V			320	µA
		DV_{DD} = 3.3V			180	
LCD DRIVER						
RMS Segment-On Voltage				1.92 x DV_{DD}		V
RMS Segment-Off Voltage				1 / 3 x DV_{DD}		V
Display Multiplex Rate				107		Hz
LCD Data-Update Rate				2.5		Hz

Note 1: Integral nonlinearity is the derivation of the analog values at any code from its theoretical value after nulling the gain error and offset error.

Note 2: Offset calibrated.

Note 3: Offset nulled.

Note 4: The input voltage range for the analog inputs is given with respect to the voltage on the negative input of the differential pair.

Note 5: For the range of V_{AIN+} or V_{AIN-} = -2.2V to +2.2V and V_{REF+} or V_{REF-} = -2.2V to +2.2V.

Note 6: External load must be constant during conversion for specified accuracy. Guaranteed specification of 2mV/mA is a result of production test limitations.

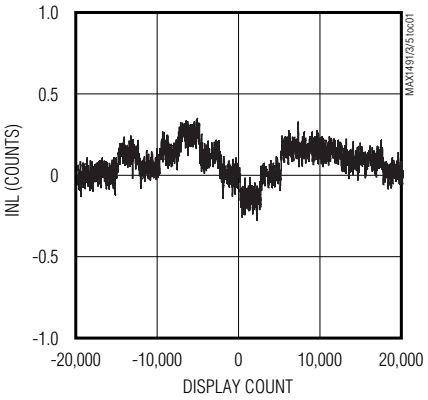
Note 7: Measured at DC by changing the power-supply voltage from 2.7V to 5.25V and measuring its effect on the conversion error. PSRR at 50Hz and 60Hz exceeds 120dB with filter notches of 10, 20, 30, 40, 50, or 60 Hz.

Note 8: Analog power-supply currents are measured with all digital inputs at either GND or DV_{DD}. Digital power-supply currents measured with all digital inputs at either GND or DV_{DD}.

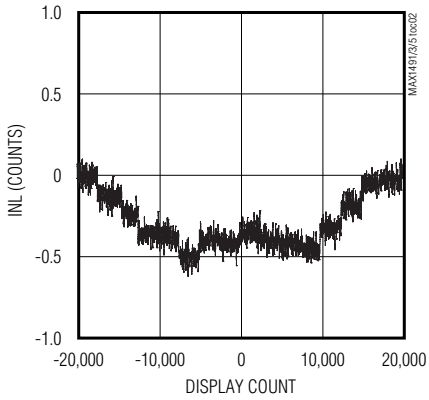
Typical Operating Characteristics

(AV_{DD} = DV_{DD} = 5V, GND = 0, REF+ = 2.048V, REF- = GND, RANGE = DV_{DD}, T_A = +25°C.)

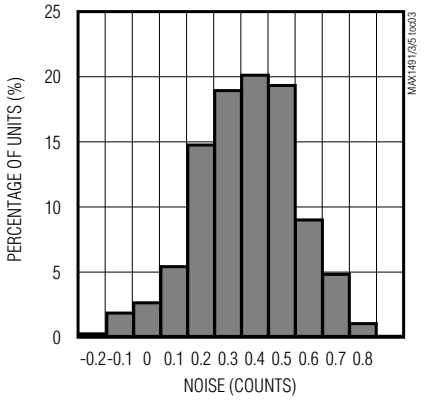
MAX1493/MAX1495 (±200mV INPUT RANGE) INL vs. DISPLAY COUNT



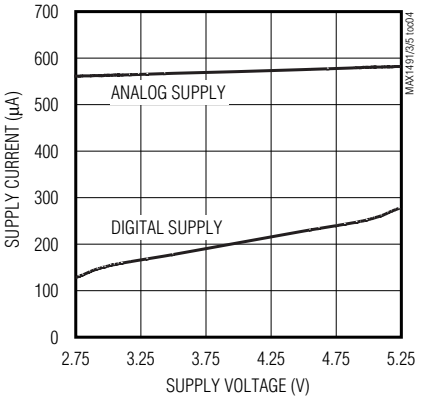
MAX1493/MAX1495 (±2V INPUT RANGE) INL vs. DISPLAY COUNT



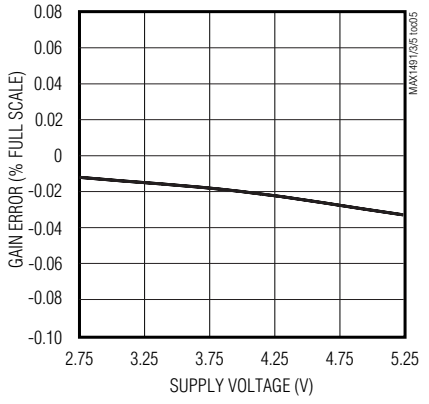
NOISE DISTRIBUTION



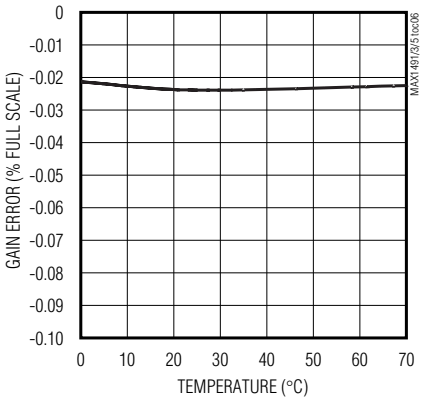
SUPPLY CURRENT vs. SUPPLY VOLTAGE



MAX1493/MAX1495 GAIN ERROR vs. SUPPLY VOLTAGE



MAX1493/MAX1495 GAIN ERROR vs. TEMPERATURE

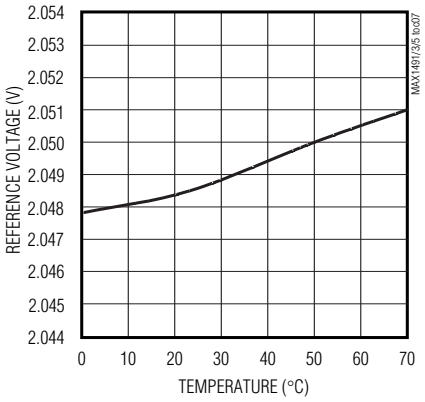


3.5- and 4.5-Digit, Single-Chip ADCs with LCD Drivers

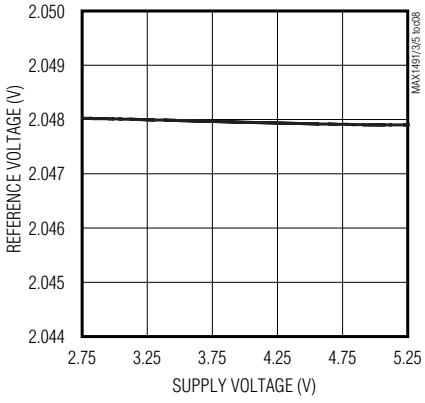
Typical Operating Characteristics (continued)

(AV_{DD} = DV_{DD} = 5V, GND = 0, REF+ = 2.048V, REF- = GND, RANGE = DV_{DD}, T_A = +25°C.)

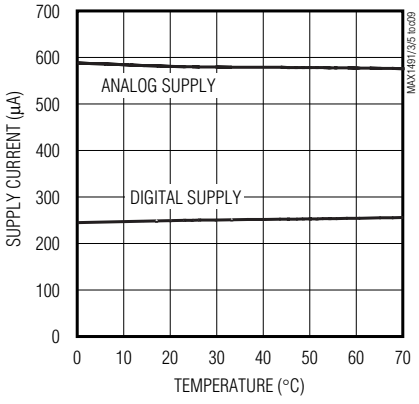
INTERNAL REFERENCE VOLTAGE vs. TEMPERATURE



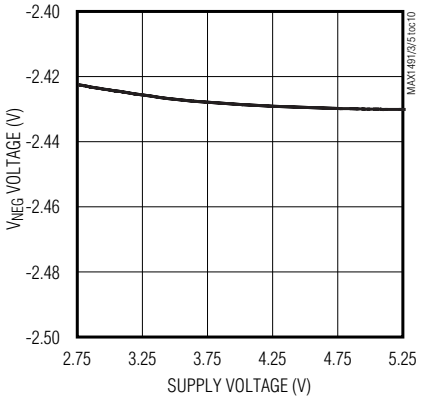
INTERNAL REFERENCE VOLTAGE vs. ANALOG SUPPLY VOLTAGE



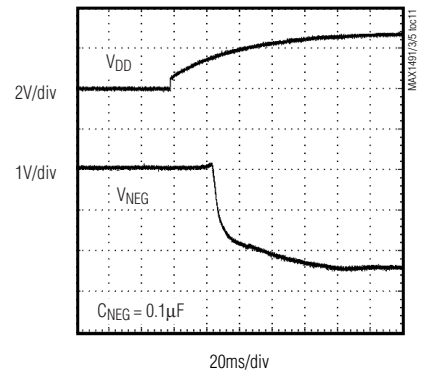
SUPPLY CURRENT vs. TEMPERATURE



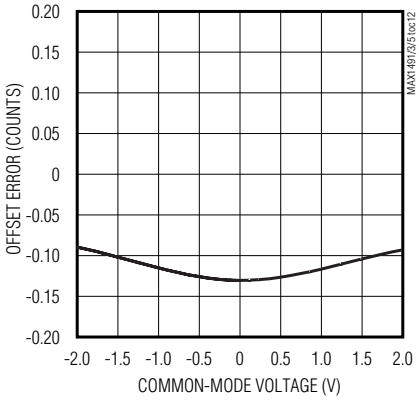
CHARGE-PUMP OUTPUT VOLTAGE vs. ANALOG SUPPLY VOLTAGE



V_{NEG} STARTUP SCOPE SHOT



OFFSET ERROR vs. COMMON-MODE VOLTAGE



Pin Description

PIN		NAME	FUNCTION
MAX1491	MAX1493 MAX1495		
1	30	INTREF	Internal Reference Logic Input. Connect to GND to select external reference mode. Connect to DV_{DD} to select the internal reference mode.
2	31	DV_{DD}	Digital Power Input. Connect DV_{DD} to a 2.7V to 5.25V power supply. Bypass DV_{DD} to GND with a 0.1µF and a 4.7µF capacitor.
3	32	GND	Ground
4	1	AV_{DD}	Analog Power Input. Connect AV_{DD} to a 2.7V to 5.25V power supply. Bypass AV_{DD} to GND with a 0.1µF and a 4.7µF capacitor.
5	2	AIN+	Positive Analog Input. Positive side of fully differential analog input. Bypass A_{IN+} to GND with a 0.1µF or greater capacitor.
6	3	AIN-	Negative Analog Input. Negative side of fully differential analog input. Bypass A_{IN-} to GND with a 0.1µF or greater capacitor.
7	4	REF-	Negative Reference Input. For internal reference operation, connect REF- to GND. For external reference operation, bypass REF- to GND with a 0.1µF capacitor and set V_{REF-} from -2.2V to +2.2V, provided $V_{REF+} > V_{REF-}$.
8	5	REF+	Positive Reference Input. For internal reference operation, connect a 4.7µF capacitor from REF+ to GND. For external reference operation, bypass REF+ to GND with a 0.1µF capacitor and set V_{REF+} from -2.2V to +2.2V, provided $V_{REF+} > V_{REF-}$.
9	6	LOWBATT	Low Battery Input. When $V_{LOWBATT} < 2.048V$ (typ), the LOWBATT symbol on the LCD turns on.
10	7	RANGE	Range Logic Input. RANGE controls the fully differential analog input range. Connect to GND for the ±2V input range. Connect to DV_{DD} for the ±200mV input range.
11	8	DPSET1	Decimal Point Logic Input 1. Controls the decimal point of the LCD. See the *Decimal Point Control* section.
12	9	DPSET2	Decimal Point Logic Input 2. Controls the decimal point of the LCD. See the *Decimal Point Control* section.
13	10	PEAK	Peak Logic Input. Connect to DV_{DD} to display the highest ADC value on the LCD. Connect to GND to disable the peak function.
14	11	HOLD	Hold Logic Input. Connect to DV_{DD} to hold the current ADC value on the LCD. Connect to GND to update the LCD at a rate of 2.5Hz and disable the hold function. For the MAX1495, placing the device into hold mode initiates an enhanced offset calibration. Assert HOLD high for a minimum of 2s to ensure the completion of enhanced offset calibration.
15	12	SEG1	LCD Segment 1 Driver
16	13	SEG2	LCD Segment 2 Driver
17	14	SEG3	LCD Segment 3 Driver
18	15	SEG4	LCD Segment 4 Driver
19	16	SEG5	LCD Segment 5 Driver
20	17	SEG6	LCD Segment 6 Driver

3.5- and 4.5-Digit, Single-Chip ADCs with LCD Drivers

Pin Description (continued)

PIN		NAME	FUNCTION
MAX1491	MAX1493 MAX1495		
21	18	SEG7	LCD Segment 7 Driver
22	19	SEG8	LCD Segment 8 Driver
23	20	SEG9	LCD Segment 9 Driver
24	21	SEG10	LCD Segment 10 Driver
25	25	BP3	LCD Backplane 3 Driver
26	26	BP2	LCD Backplane 2 Driver
27	27	BP1	LCD Backplane 1 Driver
28	29	V_{NEG}	-2.5V Charge-Pump Voltage Output. Connect a 0.1µF capacitor from V_{NEG} to GND.
—	22	SEG11	LCD Segment 11 Driver
—	23	SEG12	LCD Segment 12 Driver
—	24	SEG13	LCD Segment 13 Driver
—	28	DPON	Decimal Point Enable Input. Controls the decimal point of the LCD. See the *Decimal Point Control* section. Connect to DV_{DD} to enable the decimal point.

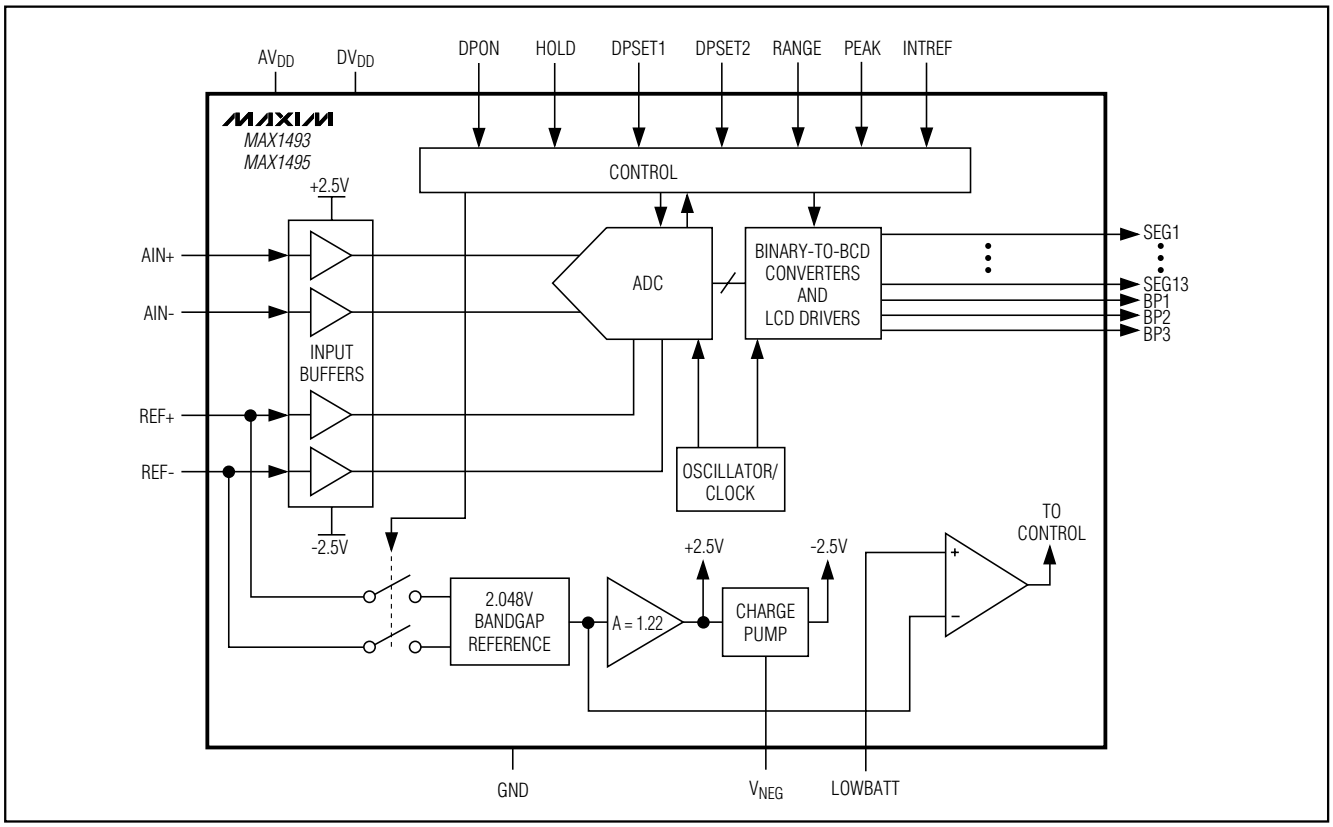


Figure 1. MAX1493/MAX1495 Functional Diagram

Detailed Description

The MAX1491/MAX1493/MAX1495 low-power, highly integrated ADCs with LCD drivers convert a ±2V differential input voltage (one count is equal to 100µV for the MAX1493/MAX1495 and 1mV for the MAX1491) with a sigma-delta ADC and output the result to an LCD. An additional ±200mV input range (one count is equal to 10µV for the MAX1493/MAX1495 and 100µV for the MAX1491) is available to measure small signals with increased resolution.

These devices operate from a single 2.7V to 5.25V power supply and offer 3.5-digit (MAX1491) or 4.5-digit (MAX1493/MAX1495) conversion results. An internal 2.048V reference, internal charge pump and a high-accuracy on-chip oscillator eliminate external components.

These devices also feature on-chip buffers for the differential input signal and external reference inputs, allowing direct interface with high-impedance signal sources. In addition, they use continuous internal offset calibration, and offer >100dB of 50Hz and 60Hz line noise rejection. Other features include data hold and peak hold, and a low-battery monitor. The MAX1495 also performs enhanced offset calibration on demand.

Analog Input Protection

Internal protection diodes limit the analog input range from V_{NEG} to (AV_{DD} + 0.3V). If the analog input exceeds this range, limit the input current to 10mA.

Internal Analog Input/ Reference Buffers

The MAX1491/MAX1493/MAX1495 analog input/reference buffers allow the use of high-impedance signal sources. The input buffers' common-mode input range allows the analog inputs and reference to range from -2.2V to +2.2V.

Modulator

The MAX1491/MAX1493/MAX1495 perform analog-to-digital conversions using a single-bit, 3rd-order, sigma-delta modulator. The sigma-delta modulation converts the input signal into a digital pulse train whose average duty cycle represents the digitized signal information. The modulator quantizes the input signal at a much higher sample rate than the bandwidth of the input.

The MAX1491/MAX1493/MAX1495 modulator provides 3rd-order frequency shaping of the quantization noise resulting from the single-bit quantizer. The modulator is fully differential for maximum signal-to-noise ratio and minimum susceptibility to power-supply noise. A single-bit data stream is then presented to the digital filter for processing, to remove the frequency-shaped quantization noise.

Digital Filtering

The MAX1491/MAX1493/MAX1495 contain an on-chip digital lowpass filter that processes the data stream from the modulator using a SINC4 $(\sin x/x)^4$ response. The $SINC^4$ filter has a settling time of four output data periods (4 x 200ms).

The MAX1491/MAX1493/MAX1495 have 25% overrange capability built into the modulator and digital filter:

$$H(f) = \left[\frac{1}{N} \frac{\sin\left(N\pi \frac{f}{f_m}\right)}{\sin\left(\pi \frac{f}{f_m}\right)} \right]^4$$

$$H(z) = \left[\frac{1}{N} \frac{\left(1 - z^{-N}\right)}{\left(1 - z^{-1}\right)} \right]^4$$

Filter Characteristics

Figure 2 shows the filter frequency response. The $SINC^4$ characteristic -3dB cutoff frequency is 0.228 times the first notch frequency (5Hz). The oversampling ratio (OSR) for the MAX1491 is 128 and the OSR for the MAX1493/MAX1495 is 1024.

The output data rate for the digital filter corresponds with the positioning of the first notch of the filter's frequency response. The notches of the $SINC^4$ filter are repeated at multiples of the first notch frequency. The $SINC^4$ filter provides an attenuation of better than 100dB at these notches. For example, 50Hz is equal to 10 times the first notch frequency and 60Hz is equal to 12 times the first notch frequency.

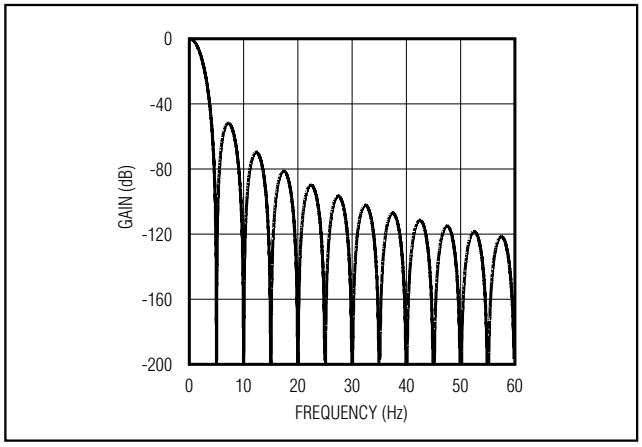


Figure 2. Frequency Response of the $SINC^4$ Filter (Notch at 60Hz)

3.5- and 4.5-Digit, Single-Chip ADCs with LCD Drivers

Internal Clock

The MAX1491/MAX1493/MAX1495 contain an internal oscillator. Using the internal oscillator saves board space by removing the need for an external clock source. The oscillator is optimized to give 50Hz and 60Hz power supply and common-mode rejection.

Charge Pump

The MAX1491/MAX1493/MAX1495 contain an internal charge pump to provide the negative supply voltage for the internal analog input/reference buffers. The bipolar input range of the analog input/reference buffers allows the devices to accept negative inputs with high source impedances. For the charge pump to operate correctly, connect a 0.1µF capacitor from V_{NEG} to GND.

LCD Driver

The MAX1491/MAX1493/MAX1495 contain the necessary backplane and segment driver outputs to drive 3.5-digit (MAX1491) and 4.5-digit (MAX1493/MAX1495) LCDs. The LCD update rate is 2.5Hz. Figures 4–7 show the connection schemes for a standard LCD. The MAX1491/MAX1493/MAX1495 automatically display the results of the ADC.

Triplexing

An internal resistor string of three equal-value resistors (52kΩ, 1% matching) is used to generate the display drive voltages. One end of the string is connected to DV_{DD} and the other end is connected to GND. Note that V_{LCD} (V_{LCD} = DV_{DD} - GND) should be three times the threshold voltage for the liquid-crystal material used.

The connection diagram for a typical 7-segment display font with two annunciators is illustrated in Figure 3 and Figure 8. The MAX1491/MAX1493/MAX1495 numeric display drivers (4.5 digits, 3.5 digits) use this configuration to drive a triplexed LCD with three backplanes and 13 segment driver lines (10 for 3.5 digits). Figures 4 and 5 show the assignment of the 4.5-digit display segments and Figures 6 and 7 show the assignment of the 3.5-digit display segments.

Table 1. List of LCD Manufacturers

MANUFACTURER	WEBSITE
DCI, Inc.	www.dciincorporated.com
LXD, Inc.	www.lxdinc.com
Varitronix International Limited	www.varitronix.com
The following site has more links to custom LCD manufacturers: www.earthlcd.com/mfr.htm	

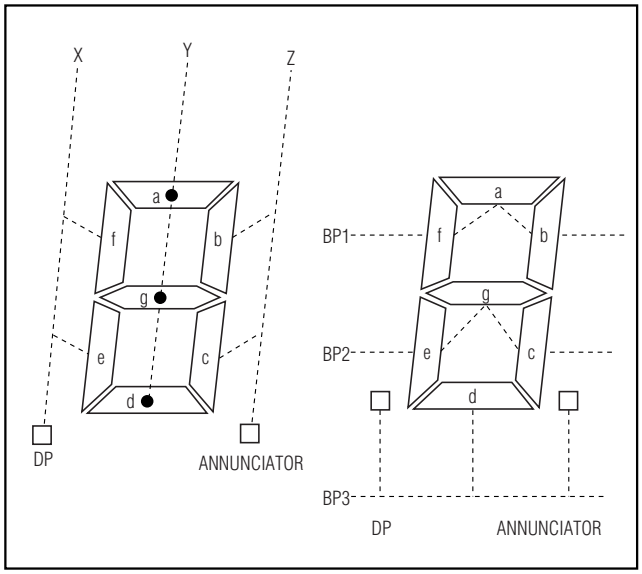


Figure 3. Connection Diagrams for Typical Seven-Segment Displays

The voltage waveforms of the backplane lines and y segment line (Figure 3) have been chosen as an example. This line intersects with BP1 to form the a segment, with BP2 to form the g segment, and with BP3 to form the d segment. Eight different ON/OFF combinations of the a, g, and d segments and their corresponding waveforms of the y segment line are illustrated in Figures 9 and 10. The schematic diagram in Figure 8 shows that each intersection acts as a capacitance from segment line to common line. Figure 11 illustrates the voltage across the g segment.

The RMS voltage across the segment determines the degree of polarization for the liquid-crystal material and thus the contrast of the segment. The RMS OFF voltage is always V_{LCD} / 3, whereas the RMS ON voltage is always $1.92V_{LCD}$ / 3. This is illustrated in Figure 11. The ratio of RMS ON to OFF voltage is fixed at 1.92 for a triplexed LCD.

Figure 12 illustrates contrast vs. applied RMS voltage with a V_{LCD} of 3.1V. The RMS ON voltage is 2.1V and the RMS OFF voltage is 1.1V. The OFF segment has a contrast of less than 5%, while the ON segments have greater than 85% contrast.

If ghosting is present on the LCD, the RMS OFF voltage is too high. Choose an LCD with a higher RMS OFF voltage or decrease DV_{DD}.

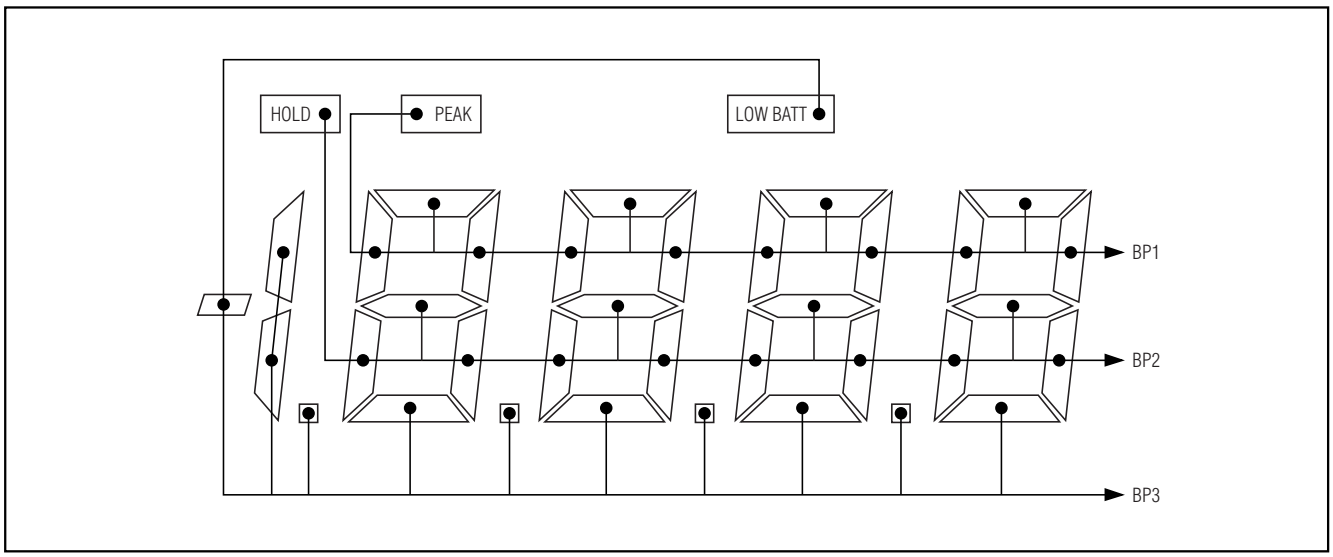


Figure 4. Backplane Connection for the MAX1493/MAX1495 (4.5 Digits)

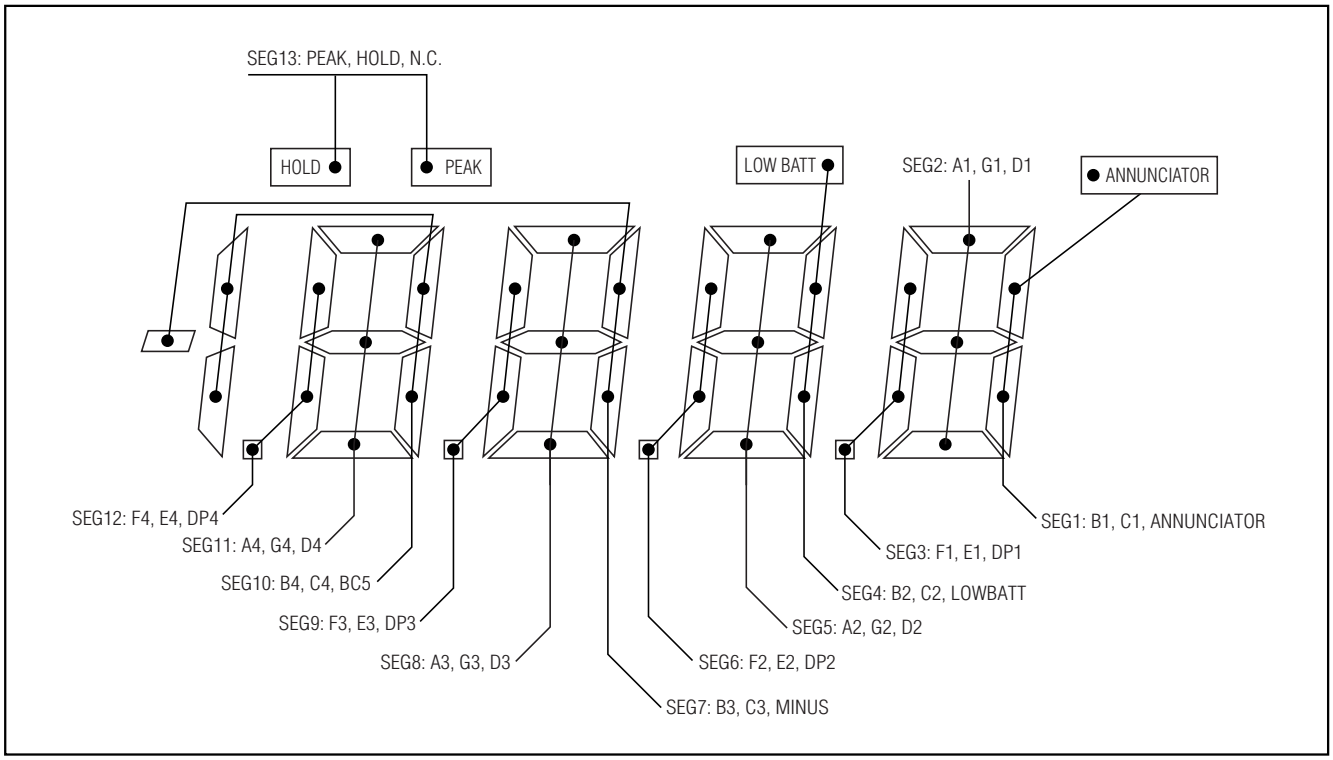


Figure 5. Segment Connection for the MAX1493/MAX1495 (4.5 Digits)

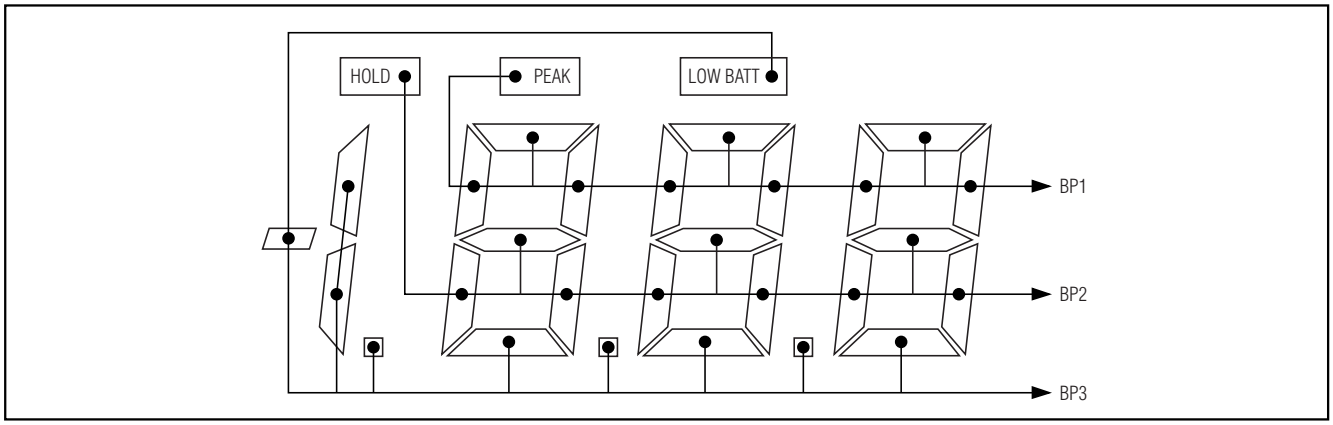


Figure 6. Backplane Connection for the MAX1491 (3.5 Digits)

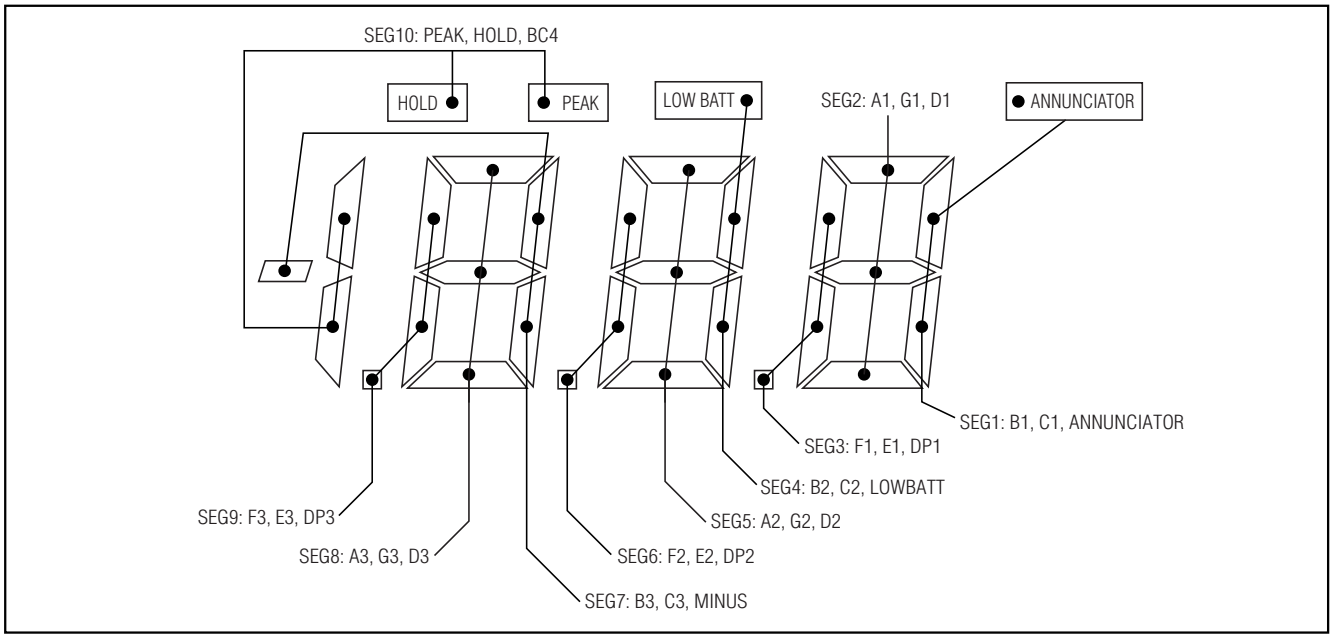


Figure 7. Segment Connection for the MAX1491 (3.5 Digits)

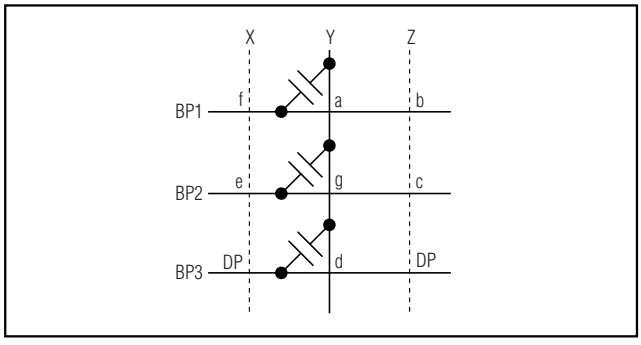


Figure 8. Schematic of Display Digit

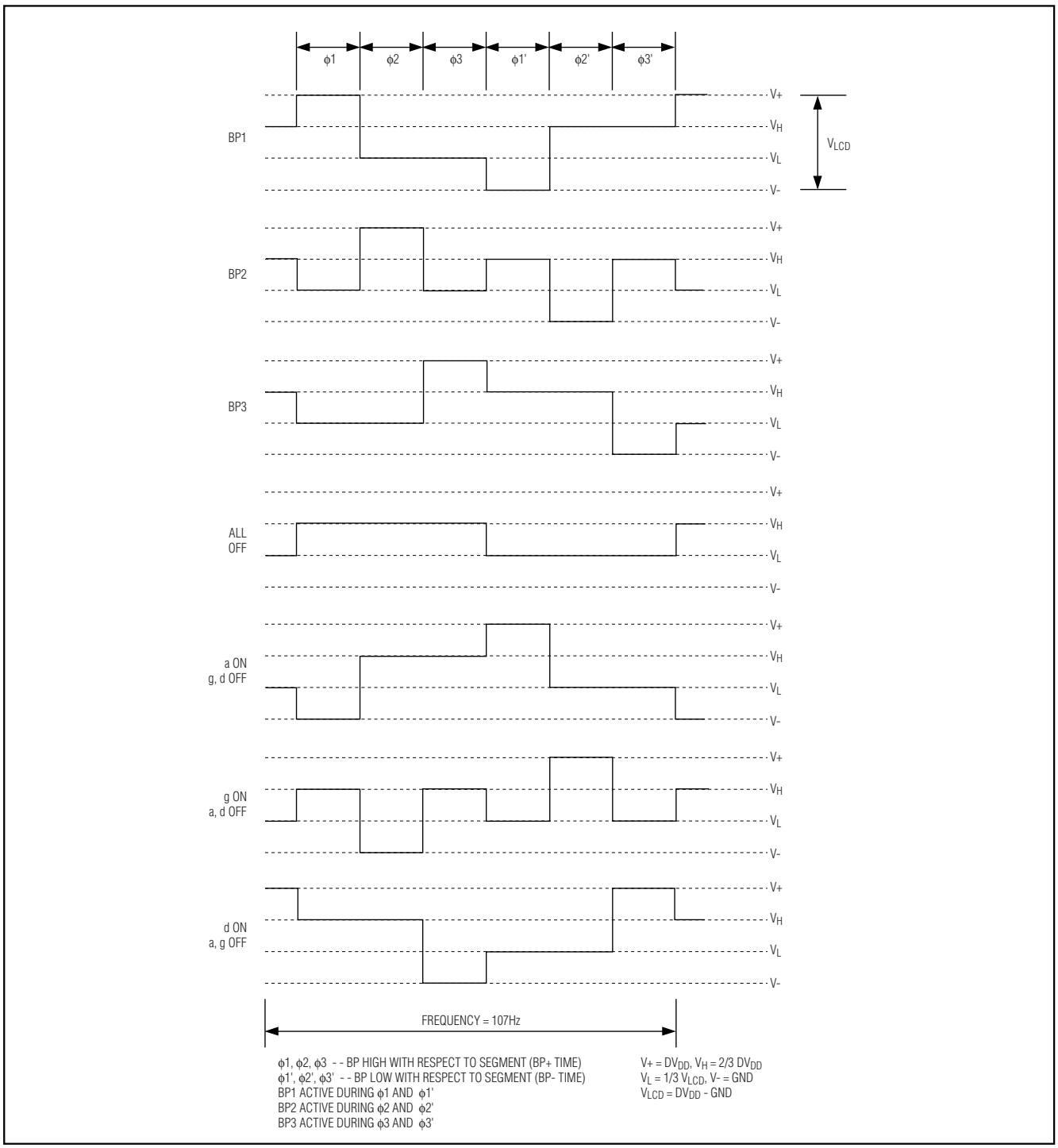


Figure 9. LCD Voltage Waveform—Combinations 1–4 (BP1/2/3, SEGa/d/g)

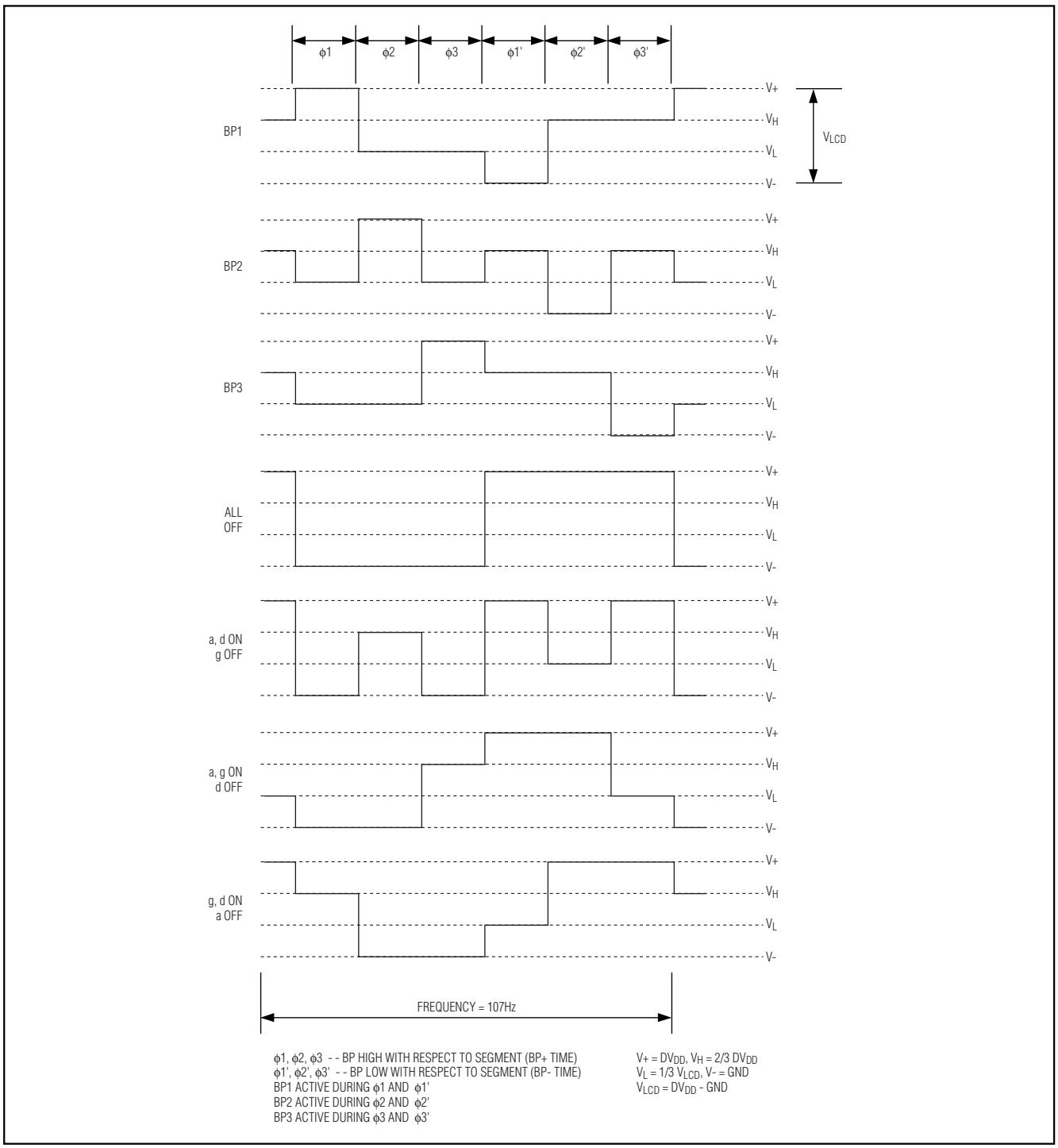


Figure 10. LCD Voltage Waveform—Combinations 5–8 (BP1/2/3, SEGa/d/g)

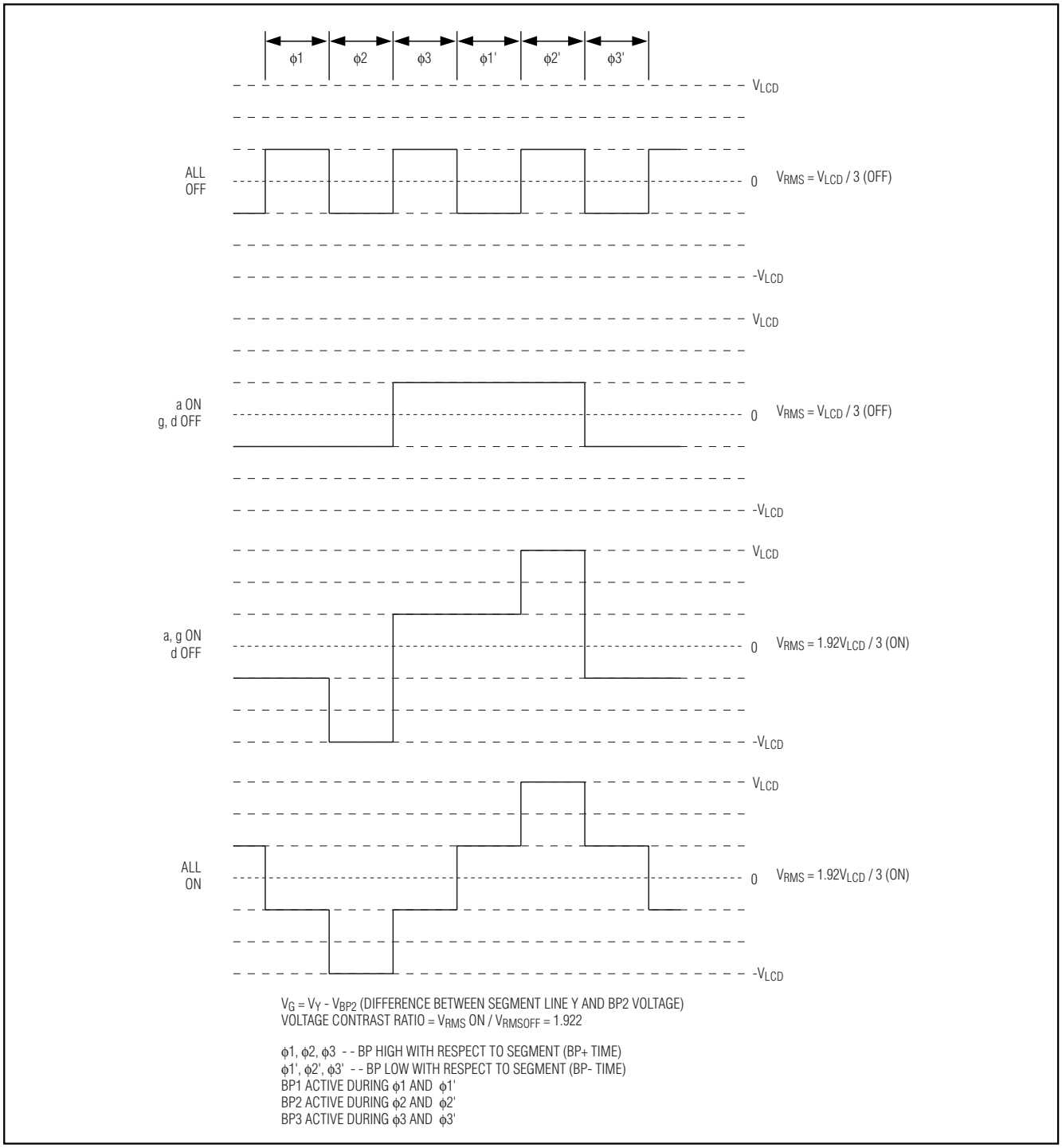
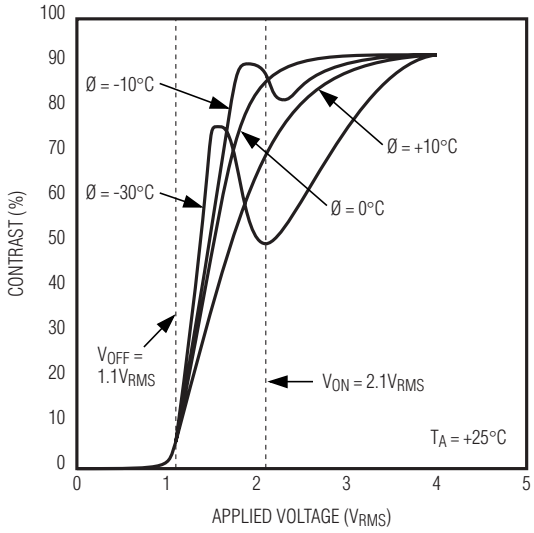


Figure 11. Voltage Waveforms on the g Segment



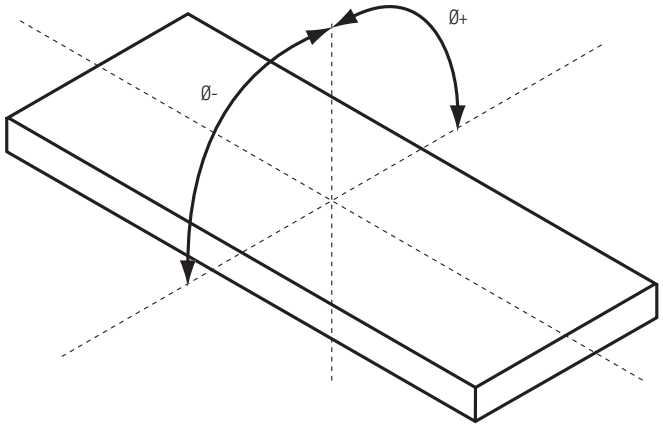


Figure 12. Contrast vs. Applied RMS Voltage

Decimal Point Control

The MAX1491/MAX1493/MAX1495 allow for full decimal-point control and feature leading-zero suppression. Use DPON, DPSET1, and DPSET2 to set the value of the decimal point. Tables 2 and 3 show the truth tables of the DPON, DPSET1, and DPSET2 that determine which decimal point is used.

Reference

The MAX1491/MAX1493/MAX1495 reference sets the full-scale range of the ADC transfer function. With a nominal 2.048V reference, the ADC full-scale range is ±2V with RANGE equal to GND. With RANGE equal to DV_{DD}, the full-scale range is ±200mV. A decreased reference voltage decreases full-scale range (see the *Transfer Functions* section).

The MAX1491/MAX1493/MAX1495 accept either an external reference or an internal reference. The INTREF input selects the reference mode.

For internal reference operation, connect INTREF to DV_{DD}, connect REF- to GND, and bypass REF+ to GND with a 4.7µF capacitor. The internal reference provides a nominal 2.048V source between REF+ and GND. The internal reference temperature coefficient is typically 40ppm/°C.

Connect INTREF to GND to use the external reference. The external reference inputs, REF+ and REF-, are fully differential. For a valid external reference input, V_{REF+} must be greater than V_{REF-}. Bypass REF+ and REF- with a 0.1µF or greater capacitor to GND in external reference mode.

Figure 13 shows the MAX1493/MAX1495 operating with an external differential reference. In this mode, REF- is connected to the top of the strain gauge and REF+ is connected to the midpoint of the resistor-divider on the supply.

Applications Information

Power-On

At power-on, the digital filter and modulator circuits reset. The MAX1493/MAX1495 allow 6s for the reference to stabilize before performing enhanced offset calibration. During these 6s, the MAX1493/MAX1495 display 1.2V to 1.5V when a stable reference is detected. If a valid reference is not found, the MAX1493/MAX1495 time out after 6s and begin enhanced offset calibration. Enhanced offset calibration typically lasts 2s. The MAX1493/MAX1495 begin converting after enhanced offset calibration.

Offset Calibration

The MAX1491/MAX1493/MAX1495 offer on-chip offset calibration. The MAX1491/MAX1493/MAX1495 calibrate offset during every conversion cycle. The MAX1495 offers enhanced offset calibration on demand. Connect HOLD to DV_{DD} for 2s to perform enhanced offset calibration.

Table 2. Decimal-Point Control Table (MAX1493/MAX1495)

DPON	DPSET1	DPSET2	DISPLAY OUTPUT	ZERO INPUT READING
0	0	0	18888	0
0	0	1	18888	0
0	1	0	18888	0
0	1	1	18888	0
1	0	0	1888.8	0.0
1	0	1	188.88	0.00
1	1	0	18.888	0.000
1	1	1	1.8888	0.0000

Table 3. Decimal-Point Control Table (MAX1491)

DPSET1	DPSET2	DISPLAY OUTPUT	ZERO INPUT READING
0	0	188.8	0.0
0	1	18.88	0.00
1	0	1.888	0.000
1	1	1888	000

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Peak

The MAX1491/MAX1493/MAX1495 feature peak detection circuitry. When activated (PEAK connected to DV_{DD}), the devices display only the highest voltage measured to the LCD. First, the current ADC result is displayed. Then the new ADC conversion result is compared to this value. If the new value is larger than the previous peak value, the new value is displayed. If the new value is less than the previous peak value, the display remains unchanged. Connect PEAK to GND to clear the peak value and disable the peak function. The peak function is only valid for the -19,487 to +19,999 range for the MAX1493/MAX1495 and -1217 to +1999 for the MAX1491.

Hold

The MAX1491/MAX1493/MAX1495 feature data HOLD circuitry. When activated (HOLD connected to DV_{DD}), the devices hold the current reading on the LCD.

Low Battery

The MAX1491/MAX1493/MAX1495 feature a low-battery detection input. When the voltage at LOWBATT drops below 2.048V (typ), the LOWBATT segment of the LCD turns on.

Strain Gauge Measurement

Connect the differential inputs of the MAX1491/MAX1493/MAX1495 to the bridge network of the strain gauge. In Figure 13, the analog supply voltage powers the bridge network and the MAX1491/MAX1493/MAX1495 along with its reference voltage. The MAX1491/MAX1493/MAX1495 handle an analog input voltage range of ±200mV or ±2V full scale. The analog/reference inputs of the part allow the analog input range to have an absolute value anywhere between -2.2V and +2.2V.

4–20mA Measurement

To measure 4–20mA signals, connect a shunt resistor across AIN+ and AIN- to create the ±2V or ±200mV input voltage (see Figure 14).

Table 4. LCD Priority Table

HOLD	PEAK	DISPLAYS
DV_{DD}	X	Current value
GND	DV_{DD}	Peak value
GND	GND	Latest ADC result

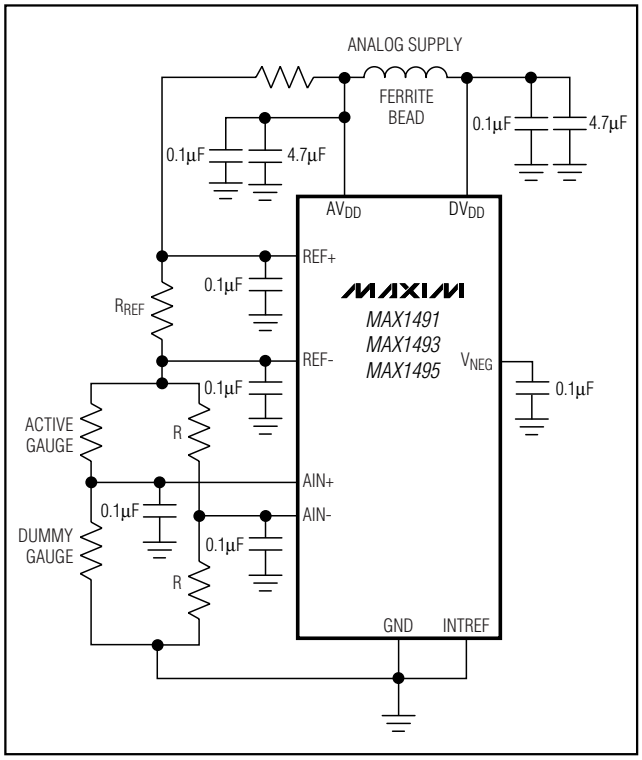


Figure 13. Strain-Gauge Application with the MAX1491/MAX1493/MAX1495

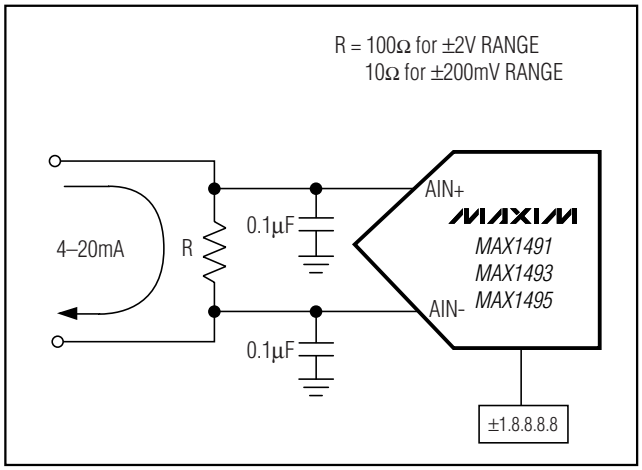


Figure 14. 4–20mA Measurement

Transfer Functions

Figures 15–18 show the MAX1491/MAX1493s' transfer functions. The transfer function for the MAX1493/MAX1495 with AIN+ - AIN- ≥ 0 and RANGE = GND is:

$$Counts = 1.024 \times \left(\frac{V_{AIN+} - V_{AIN-}}{V_{REF+} - V_{REF-}} \right) \times 20{,}000$$

The transfer function for the MAX1493 with AIN+ - AIN- < 0 and RANGE = GND is:

$$Counts = 1.024 \times \left(\frac{V_{AIN+} - V_{AIN-}}{V_{REF+} - V_{REF-}} \times 20{,}000 \right) + 1$$

The transfer function for the MAX1491 with AIN+ - AIN- ≥ 0 and RANGE = GND is:

$$Counts = 1.024 \times \left(\frac{V_{AIN+} - V_{AIN-}}{V_{REF+} - V_{REF-}} \right) \times 2000$$

The transfer function for the MAX1491 with AIN+ - AIN- < 0 and RANGE = GND is:

$$Counts = 1.024 \times \left(\frac{V_{AIN+} - V_{AIN-}}{V_{REF+} - V_{REF-}} \times 2000 \right) + 1$$

The transfer function for the MAX1493/MAX1495 with AIN+ - AIN- ≥ 0 and RANGE = DV_{DD} is:

$$Counts = 1.024 \times \left(\frac{V_{AIN+} - V_{AIN-}}{V_{REF+} - V_{REF-}} \right) \times 20{,}000 \times 10$$

The transfer function for the MAX1493 with AIN+ - AIN- < 0 and RANGE = DV_{DD} is:

$$Counts = 1.024 \times \left(\frac{V_{AIN+} - V_{AIN-}}{V_{REF+} - V_{REF-}} \times 20{,}000 \right) \times 10 + 1$$

The transfer function for the MAX1491 with AIN+ - AIN- ≥ 0 and RANGE = DV_{DD} is:

$$Counts = 1.024 \times \left(\frac{V_{AIN+} - V_{AIN-}}{V_{REF+} - V_{REF-}} \right) \times 2000 \times 10$$

The transfer function for the MAX1491 with AIN+ - AIN- < 0 and RANGE = DV_{DD} is:

$$Counts = 1.024 \times \left(\frac{V_{AIN+} - V_{AIN-}}{V_{REF+} - V_{REF-}} \times 2000 \right) \times 10 + 1$$

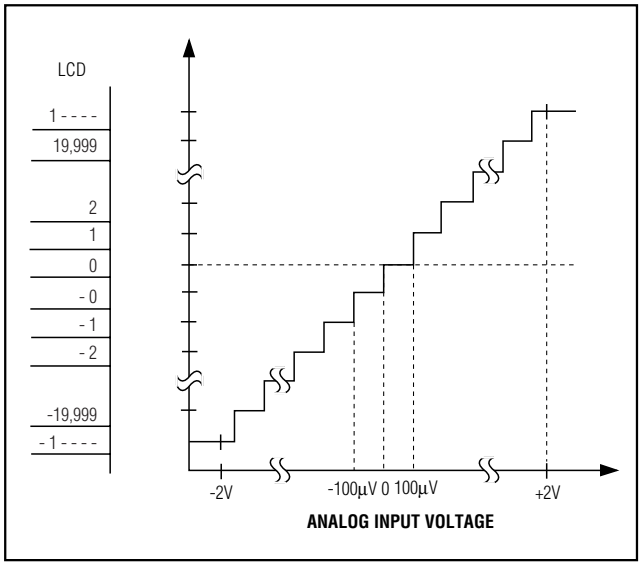


Figure 15. MAX1493/MAX1495 Transfer Function ±2V Range

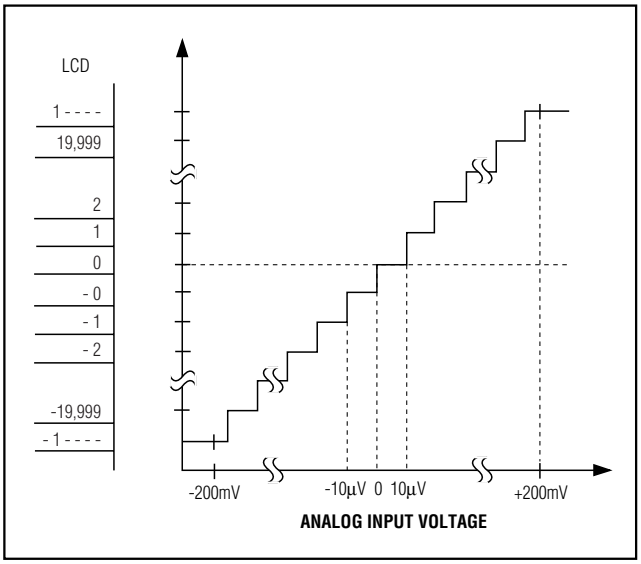


Figure 16. MAX1493/MAX1495 Transfer Function ±200mV Range

3.5- and 4.5-Digit, Single-Chip ADCs with LCD Drivers

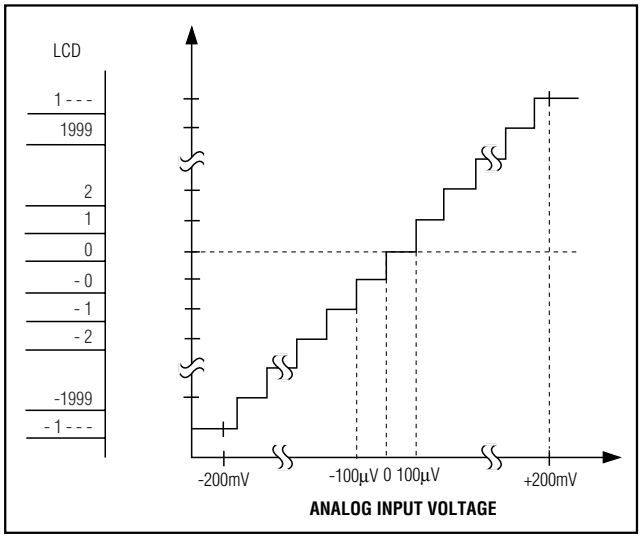


Figure 17. MAX1491 Transfer Function ±200mV Range

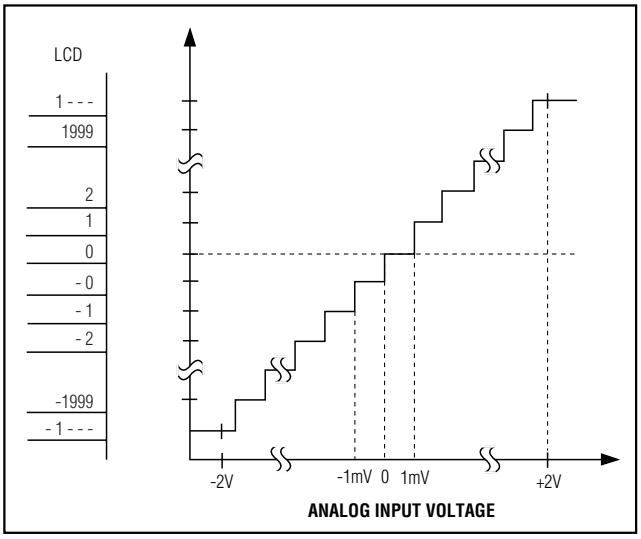


Figure 18. MAX1491 Transfer Function ±2V Range

Supplies, Layout, and Bypassing

Power up AV_{DD} and DV_{DD} before applying an analog input and external reference voltage to the device. If this is not possible, limit the current into these inputs to 50mA. Isolate the digital supply from the analog supply with a low-value resistor (10Ω) or ferrite bead when the analog and digital supplies come from the same source. For best performance, ground the MAX1491/MAX1493/MAX1495 to the analog ground plane of the circuit board.

Avoid running digital lines under the device, because these may couple noise onto the die. Run the analog ground plane under the MAX1491/MAX1493/MAX1495 to minimize coupling of digital noise. Make the power-supply lines to the MAX1491/MAX1493/MAX1495 as wide as possible to provide low-impedance paths and reduce the effects of glitches on the power-supply line.

Shield fast-switching signals, such as clocks, with digital ground to avoid radiating noise to other sections of the board. Avoid running clock signals near the analog inputs. Avoid crossover of digital and analog signals. Running traces that are on opposite sides of the board at right angles to each other reduces feedthrough effects.

Good decoupling is important when using high-resolution ADCs. Decouple the supplies with 4.7µF and 0.1µF ceramic capacitors to GND. Place these components as close to the device as possible to achieve the best decoupling.

Refer to the MAX1494 evaluation kit manual for the recommended layout. The evaluation board package includes a fully assembled and tested evaluation board.

Definitions

INL

Integral nonlinearity (INL) is the deviation of the values on an actual transfer function from a straight line. This straight line is either a best-straight-line fit or a line drawn between the end points of the transfer function, once offset and gain errors have been nullified. INL for the MAX1491/MAX1493/MAX1495 is measured using the end-point method.

DNL

Differential nonlinearity (DNL) is the difference between an actual step width and the ideal value of one count. A DNL error specification of less than one count guarantees no missing counts and a monotonic transfer function.

Rollover Error

Rollover error is defined as the absolute value difference between a near-positive full-scale reading and near-negative full-scale reading. Rollover error is tested by applying a full-scale positive voltage, swapping AIN+ and AIN-, and then adding the results.

Zero Input Reading

Ideally, with AIN+ connected to AIN-, the MAX1491/MAX1493/MAX1495 display a zero. Zero input reading is the measured deviation from the ideal zero and the actual measured point.

Gain Error

Gain error is the amount of deviation between the measured full-scale transition point and the ideal full-scale transition point.

Common-Mode Rejection

Common-mode rejection is the ability of a device to reject a signal that is common to both input terminals. The common-mode signal can be either an AC or a DC signal or a combination of the two. CMR is often expressed in decibels.

Normal-Mode 50Hz and 60Hz Rejection (Simultaneously)

Normal mode rejection is a measure of how much output changes when 50Hz and 60Hz signals are injected into just one of the differential inputs. The MAX1491/MAX1493/MAX1495 sigma-delta converter uses its internal digital filter to provide normal mode rejection to both 50Hz and 60Hz power-line frequencies simultaneously.

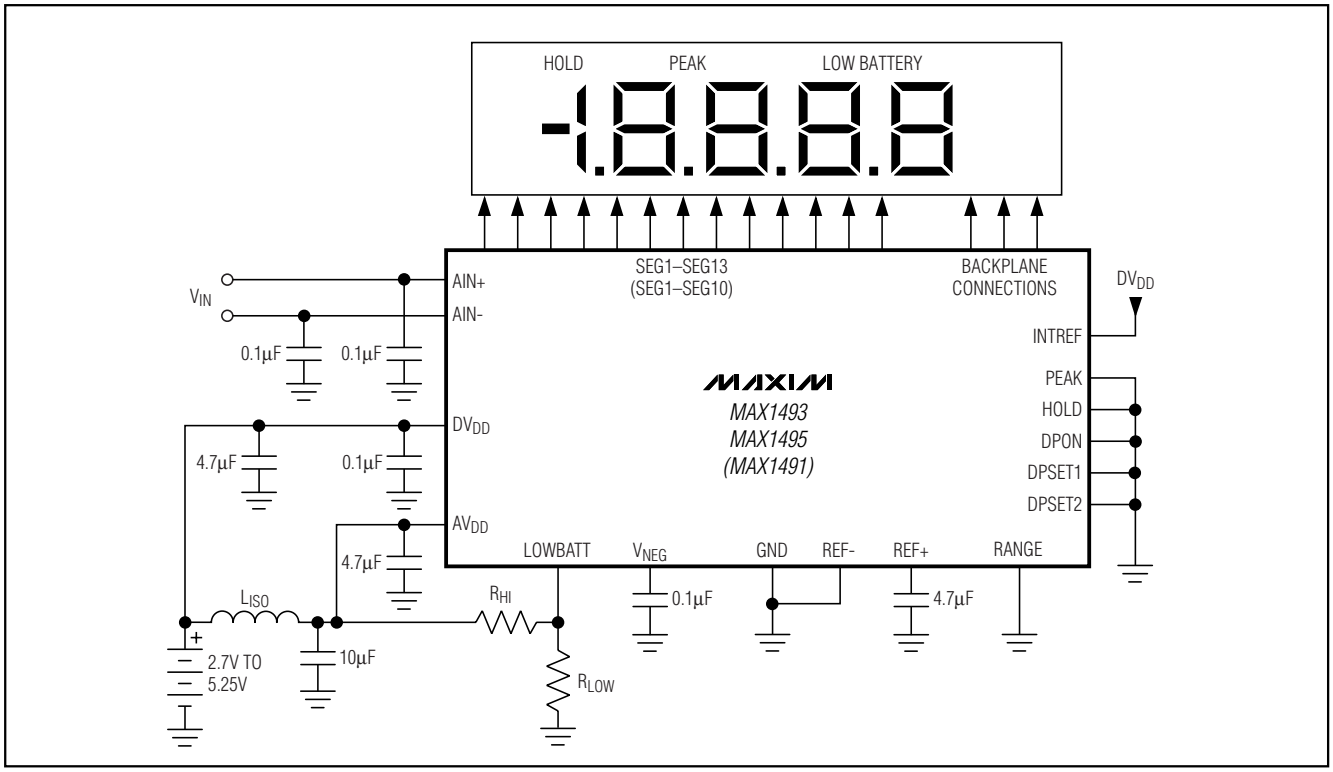
Power-Supply Rejection Ratio

Power-supply rejection ratio (PSRR) is the ratio of the input supply change (in volts) to the change in the converter output (in volts). It is measured typically in decibels.

Enhanced Offset Calibration

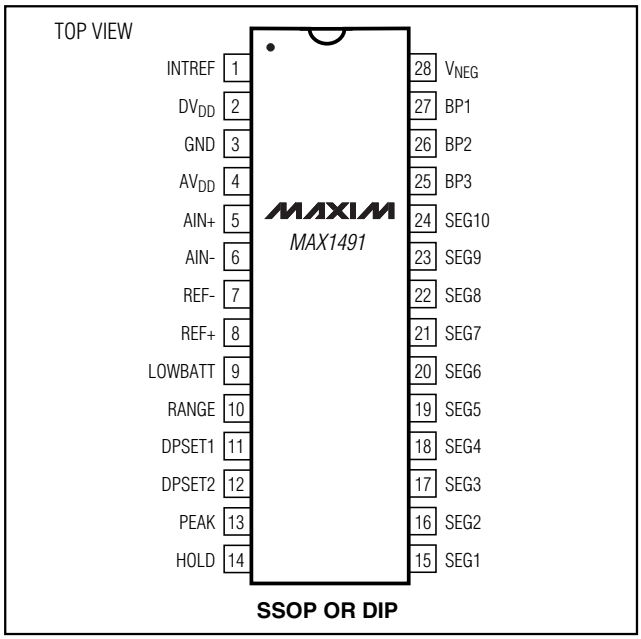
Enhanced offset calibration is a more accurate calibration method that is needed in the case of the ±200mV range and 4.5-digit resolution. The MAX1493/MAX1495 perform the enhanced offset calibration upon power-up. The MAX1495 also performs enhanced offset calibration on demand with the HOLD input.

Typical Operating Circuit



3.5- and 4.5-Digit, Single-Chip ADCs with LCD Drivers

Pin Configurations (continued)



Chip Information

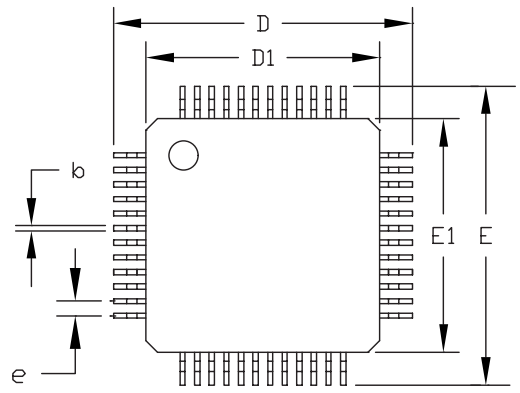
TRANSISTOR COUNT: 79,435

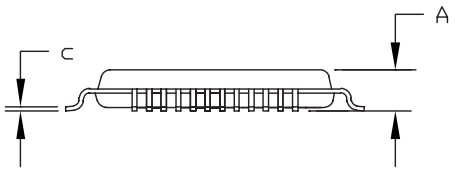
PROCESS: BiCMOS

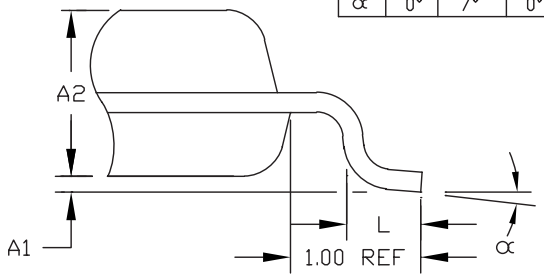
Package Information

(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**.)

32L/48L,TQFP.EPS







JEDEC VARIATION				
	BC		BE	
	32 LEAD		48 LEAD	
	MIN.	MAX.	MIN.	MAX.
A	---	1.60	---	1.60
A_1	0.05	0.15	0.05	0.15
A_2	1.35	1.45	1.35	1.45
D	8.90	9.10	8.90	9.10
D_1	7.00 BSC.		7.00 BSC.	
E	8.90	9.10	8.90	9.10
E_1	7.00 BSC.		7.00 BSC.	
e	0.8 BSC.		0.5 BSC.	
L	0.45	0.75	0.45	0.75
b	0.30	0.45	0.17	0.27
c	0.09	0.20	0.09	0.20
α	0°	7°	0°	7°

NOTES:

1. ALL DIMENSIONING AND TOLERANCING CONFORM TO ANSI Y14.5-1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. THIS OUTLINE CONFORMS TO JEDEC PUBLICATION 95 REGISTRATION MO-136, VARIATIONS BC AND BE.
4. LEADS SHALL BE COPLANAR WITHIN .004 INCH.

MAXIM

PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE, 32/48L, 7x7x1.4 MM TQFP

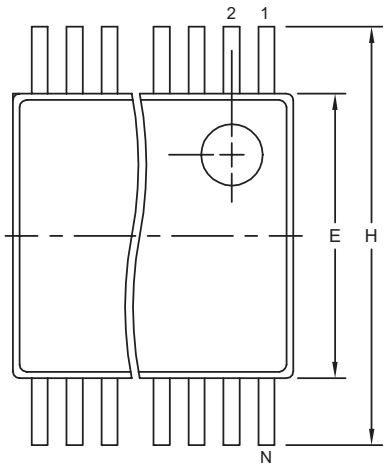
APPROVAL	DOCUMENT CONTROL NO.	REV	
	21-0054	D	1/1

3.5- and 4.5-Digit, Single-Chip ADCs with LCD Drivers

Package Information (continued)

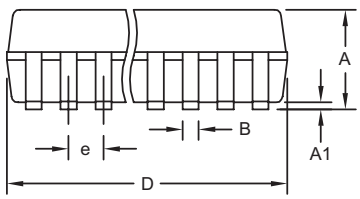
(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to **www.maxim-ic.com/packages**.)

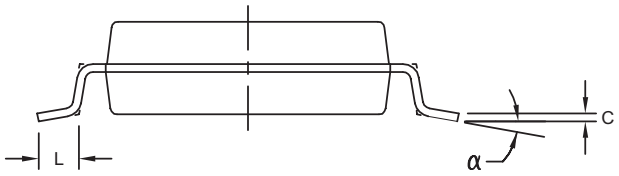
SSOP.EPS



DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.068	0.078	1.73	1.99
A1	0.002	0.008	0.05	0.21
B	0.010	0.015	0.25	0.38
C	0.004	0.008	0.09	0.20
D	SEE VARIATIONS			
E	0.205	0.212	5.20	5.38
e	0.0256 BSC		0.65 BSC	
H	0.301	0.311	7.65	7.90
L	0.025	0.037	0.63	0.95
α	0∞	8∞	0∞	8∞

	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX	N
D	0.239	0.249	6.07	6.33	14L
D	0.239	0.249	6.07	6.33	16L
D	0.278	0.289	7.07	7.33	20L
D	0.317	0.328	8.07	8.33	24L
D	0.397	0.407	10.07	10.33	28L





NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15 MM (.006").
3. CONTROLLING DIMENSION: MILLIMETERS.
4. MEETS JEDEC MO150.
5. LEADS TO BE COPLANAR WITHIN 0.10 MM.

DALLAS SEMICONDUCTOR MAXIM

PROPRIETARY INFORMATION

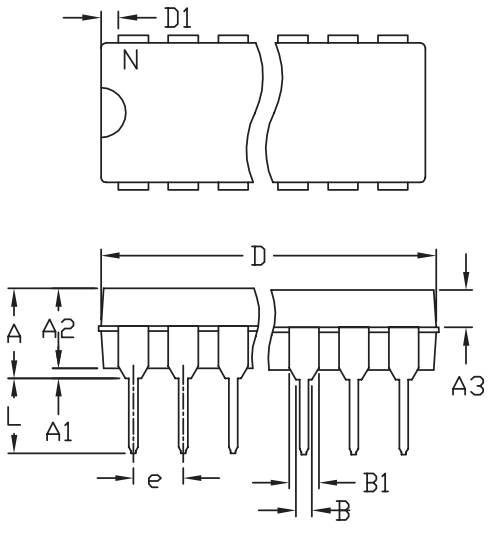
TITLE: PACKAGE OUTLINE, SSOP, 5.3 MM

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0056	C	1/1

Package Information (continued)

(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**.)

PDIPN.EPS



	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	---	0.180	---	4.572
A1	0.015	---	0.38	---
A2	0.125	0.175	3.18	4.45
A3	0.055	0.080	1.40	2.03
B	0.015	0.022	0.381	0.56
B1	0.045	0.065	1.14	1.65
C	0.008	0.014	0.2	0.355
D1	0.005	0.080	0.13	2.03
E	0.300	0.325	7.62	8.26
E1	0.240	0.310	6.10	7.87
e	0.100 BSC.		2.54 BSC.	
eA	0.300 BSC.		7.62 BSC.	
eB	0.400 BSC.		10.16 BSC.	
L	0.115	0.150	2.921	3.81

	INCHES		MILLIMETERS			
	MIN	MAX	MIN	MAX	N	MS001
D	0.348	0.390	8.84	9.91	8	AB
D	0.735	0.765	18.67	19.43	14	AC
D	0.745	0.765	18.92	19.43	16	AA
D	0.885	0.915	22.48	23.24	18	AD
D	1.015	1.045	25.78	26.54	20	AE
D	1.14	1.265	28.96	32.13	24	AF
D	1.360	1.380	34.54	35.05	28	*5

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006")
3. CONTROLLING DIMENSION: MILLIMETER
4. MEETS JEDEC MS001-XX AS SHOWN IN ABOVE TABLE
5. SIMILIAR TO JEDEC MO-058AB
6. N = NUMBER OF PINS

MAXIM 120 SAN GABRIEL DR SUNNYVALE CA 94086 FAX (408) 737 7194
PROPRIETARY INFORMATION

PACKAGE FAMILY OUTLINE: PDIP .300" (TITLE)

1/1

21-0043 D (DOCUMENT CONTROL NUMBER) REV