MP8784

CMOS
5 MSPS, 10-Bit, High Speed
Analog-to-Digital Converter

March 1998-3

FEATURES

- 10-Bit Resolution
- Sampling Rate to 5 MSPS
- DNL = ±1 LSB, INL = ±2 LSB
- Internal S/H Function
- Single 5 V Power Supply
- V_{IN} DC Range: 0 V to V_{DD}
- V_{REF} DC Range: 1 V to V_{DD}
- Low Power: 175 mW
- Three-State Digital Outputs
- Latch-Up Free
- 3 V Version: MP87L84

APPLICATIONS

- Digital Color Copiers
- Digital Cellular Telephones
- Precision CCDs and Scanners
- Medical Scanners
- Ultrasonics
- Digital Radio

BENEFITS

- Simplified Analog Design
- Rugged
- Few External Components, no S/H Needed
- Reduced Board Space

GENERAL DESCRIPTION

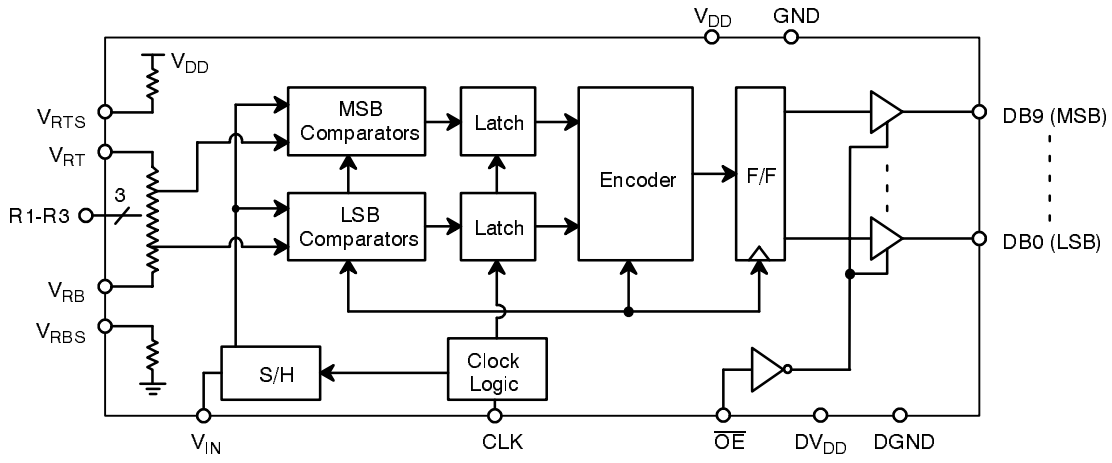
The MP8784 is a 10-bit, 5 MSPS, Analog-to-Digital Converter for applications that require high speed and high accuracy. Designed using an advanced CMOS process, this part offers excellent performance, low power consumption and latch-up free operation.

The MP8784 uses a subranging architecture to maintain low power consumption at high conversion rates. Our proprietary comparator design achieves a low analog input capacitance. The input circuitry of the MP8784 includes an on-chip S/H function that allows this part to digitize analog input signals between AGND and AV_{DD}.

The designer can choose the internally generated reference voltages, or provide external reference voltages to the V_{RB} and V_{RT} pins. The internal reference generates 1.0 V at V_{RB} and 4 V at V_{RT}. Providing external reference voltages allows easy interface to any input signal range between GND and V_{DD}. This also allows the system to cancel zero scale and full scale errors. The Reference Ladder taps (R1 to R3) can be used to externally trim any INL errors.

This device operates from a single 5 V supply. Power consumption from a 5 V supply is typically 175 mW at F_S=5MHz, and only 150 mW at F_S=1MHz.

SIMPLIFIED BLOCK DIAGRAM



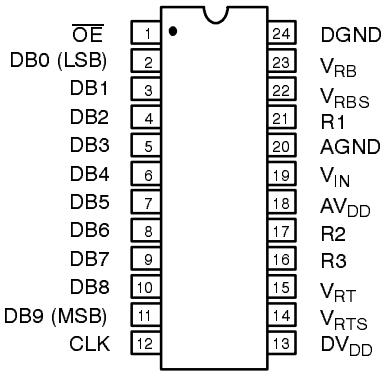
EXAR Corporation, 48720 Kato Road, Fremont, CA 94538 ◆ (510) 668-7000 ◆ (510) 668-7017

ORDERING INFORMATION

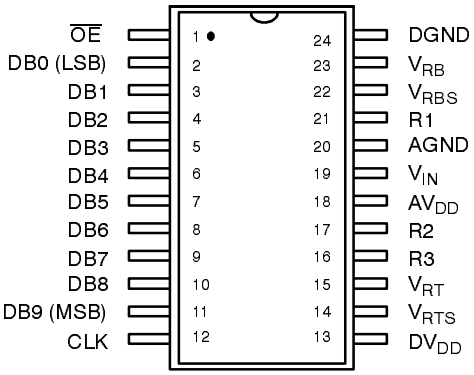
Package Type	Temperature Range	Part No.	DNL (LSB)	INL (LSB)
Plastic Dip	–40 to +85°C	MP8784AN	±1	±2
SOIC	–40 to +85°C	MP8784AS	±1	±2

PIN CONFIGURATIONS

See Packaging Section for Package Dimensions



24 Pin PDIP (0.300")



24 Pin SOIC (Jedec, 0.300")

PIN OUT DEFINITIONS

PIN NO.	NAME	DESCRIPTION
1	$\overline{OE}$	Output Enable
2	DB0	Data Output Bit 0 (LSB)
3	DB1	Data Output Bit 1
4	DB2	Data Output Bit 2
5	DB3	Data Output Bit 3
6	DB4	Data Output Bit 4
7	DB5	Data Output Bit 5
8	DB6	Data Output Bit 6
9	DB7	Data Output Bit 7
10	DB8	Data Output Bit 8
11	DB9	Data Output Bit 9 (MSB)
12	CLK	Clock Input

PIN NO.	NAME	DESCRIPTION
13	DV_{DD}	Digital Power Supply
14	V_{RTS}	Top Internal Reference
15	V_{RT}	Top of Reference
16	R3	3/4 Reference Tap Point
17	R2	1/2 Reference Tap Point
18	AV_{DD}	Analog Power Supply
19	V_{IN}	Analog Input Voltage
20	AGND	Analog Ground
21	R1	1/4 Reference Tap Point
22	V_{RBS}	Bottom Internal Reference
23	V_{RB}	Bottom of Reference
24	DGND	Digital Ground

ELECTRICAL CHARACTERISTICS TABLE

Unless Otherwise Specified: AV_{DD} = DV_{DD} = 5 V, FS = 5 MHz (50% Duty Cycle), V_{RT} = 4.0, V_{RB} = 1.0, TA = 25°C

Parameter	Symbol	25°C Min	25°C Typ	25°C Max	Units	Test Conditions/Comments
KEY FEATURES						
Resolution		10			Bits	
Maximum Sampling Rate	FS	5			MHz	
ACCURACY (A Grade)[1]						
Differential Non-Linearity	DNL			±1	LSB	
Integral Non-Linearity	INL			±2	LSB	Best Fit Line (Max INL – Min INL)/2
Zero Scale Error	EZS		10		LSB	
Full Scale Error	EFS		6		LSB	
REFERENCE VOLTAGES						
Positive Ref. Voltage[3]	V_{RT}			AV_{DD}	V	
Negative Ref. Voltage[3]	V_{RB}	AGND			V	
Differential Ref. Voltage[3]	V_{REF}	1.0		AV_{DD}	V	$V_{REF} = V_{RT} - V_{RB}$
Ladder Resistance	R_L		375		Ω	
Ladder Temp. Coefficient[2]	R_{TCO}		2000		ppm/°C	
Top Internal Reference	V_{RTS}		4		V	V_{RT} connected to V_{RTS} &
Bottom Internal Reference	V_{RBS}		1		V	V_{RB} connected to V_{RBS}
ANALOG INPUT[2]						
Input Bandwidth (–1 dB)[4]	BW		10		MHz	
Input Voltage Range	V_{IN}	V_{RB}		V_{RT}	V	
Input Capacitance Sample[5]	C_{IN}		25	40	pF	
Input Capacitance Convert[5]			5	12	pF	
Aperture Delay[2]	t_{AP}		25	30	ns	
Aperture Uncertainty [2] (Jitter)	t_{AJ}		50		ps	
DIGITAL INPUTS						
Logical "1" Voltage	V_{IH}	4			V	
Logical "0" Voltage	V_{IL}			1	V	
DC Leakage Currents[6]	I_{IN}					V_{IN}=DGND to DV_{DD}
CLK			5		µA	
$\overline{OE}$ (Internal Res to DGND)[7]			15		µA	
Input Capacitance			5		pF	
Clock Timing (*See Figure 1*)						
Clock Period	1/FS		200		ns	
Rise & Fall Time[8]	t_R, t_F		5		ns	
"High" Pulse Width[3]	t_{PWH}		100		ns	
"Low" Pulse Width[3]	t_{PWL}		100		ns	
Duty Cycle[3]			50		%	
DIGITAL OUTPUTS						C_{OUT}=15 pF
Logical "1" Voltage	V_{OH}	4.5			V	I_{LOAD} = 4 mA
Logical "0" Voltage	V_{OL}			0.4	V	I_{LOAD} = 4 mA
3-state Leakage	I_{OZ}		10		µA	V_{OUT}=DGND to DV_{DD}
Data Valid Delay[2]	t_{DL}		40	45	ns	
Data Enable Delay[2]	t_{DEN}		25	30	ns	
Data 3-state Delay[2]	t_{DHZ}		25	30	ns	

ELECTRICAL CHARACTERISTICS TABLE (CONT'D)

Description	Symbol	25°C Min	25°C Typ	25°C Max	Units	Conditions
POWER SUPPLIES						
Operating Voltage (AV_{DD}, DV_{DD}) [9, 10]	V_{DD}	4	5	6	V	
Current (AV_{DD} + DV_{DD})	I_{DD}		35	45	mA	

Notes:

1 *Tester measures code transitions by dithering the voltage of the analog input (V_{IN}). The difference between the measured and the ideal code width (V_{REF}/1024) is the DNL error (Figure 3.). The INL error is the maximum distance (in LSBs) from the best fit line to any transition voltage (Figure 4.). Accuracy is a function of the sampling rate (FS).*

2 *Guaranteed. Not tested.*

3 *Specified values guarantee functionality. Refer to other parameters for accuracy.*

4 *–1 dB bandwidth is a measure of performance of the A/D input stage (S/H + amplifier). Refer to other parameters for accuracy within the specified bandwidth.*

5 *See V_{IN} equivalent circuit (Figure 8.). Switched capacitor analog input requires driver with low output resistance.*

6 *All inputs have diodes to DV_{DD} and DGND. Input $\overline{OE}$ has internal pull down. Input DC currents will not exceed specified limits for any input voltage between DGND and DV_{DD}.*

7 *Internal resistor to DGND biases unconnected input to active low logical level.*

8 *Condition to meet aperture delay specifications (t_{AP}, t_{AJ}). Actual rise/fall time can be less stringent with no loss of accuracy.*

9 *The AGND & DGND pins are connected through the silicon substrate. Connect together at the package and to the analog ground plane.*

10 *The AV_{DD} & DV_{DD} pins should be tied together at the package.*

Specifications are subject to change without notice

ABSOLUTE MAXIMUM RATINGS (T_A = +25°C unless otherwise noted)[1, 2, 3]

V_{DD} to GND ..... +7 V
V_{RT} & V_{RB} ..... V_{DD} +0.5 to GND –0.5 V
V_{IN} ..... V_{DD} +0.5 to GND –0.5 V
All Inputs ..... V_{DD} +0.5 to GND –0.5 V
All Outputs ..... V_{DD} +0.5 to GND –0.5 V

Storage Temperature ..... –65 to +150°C
Package Power Dissipation Rating to 75°C
PDIP, SOIC ..... 1000 mW
Derates above 75°C ..... 14mW/°C
Lead Temperature (Soldering 10 seconds) ..... +300°C

Notes:

1 *Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation at or above this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.*

2 *Any input pin which can see a value outside the absolute maximum ratings should be protected by Schottky diode clamps (HP5082-2835) from input pin to the supplies. All inputs have protection diodes which will protect the device from short transients outside the supplies of less than 100mA for less than 100µs.*

3 *V_{DD} refers to AV_{DD} and DV_{DD}. GND refers to AGND and DGND.*

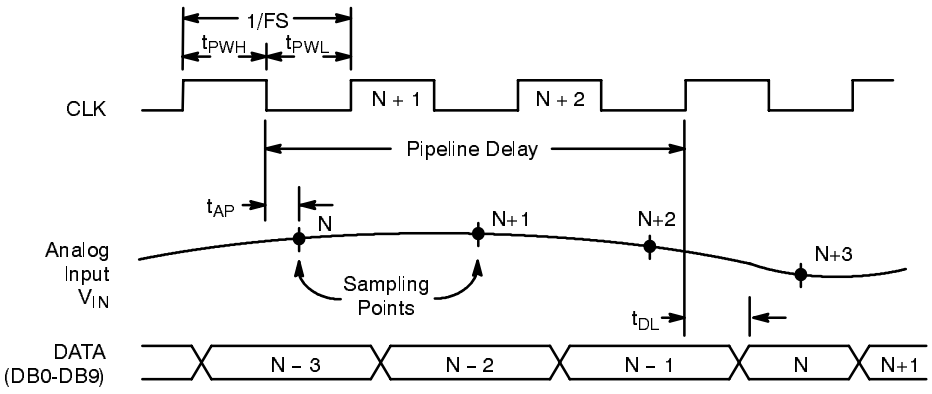


Figure 1. MP8784 Timing Diagram

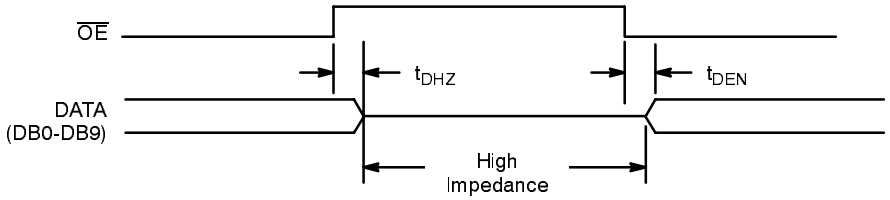
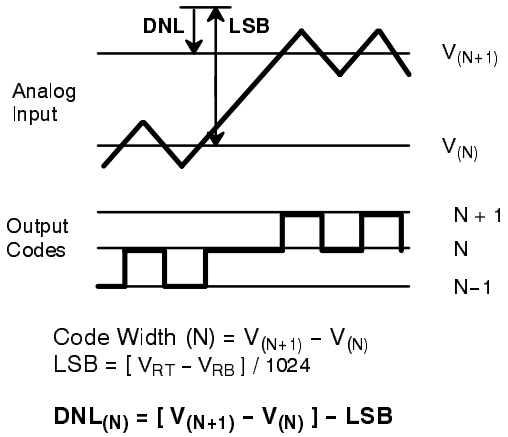


Figure 2. 3-State Timing Diagram



Code Width (N) = $V_{(N+1)} - V_{(N)}$
LSB = [$V_{RT} - V_{RB}$] / 1024

$DNL_{(N)} = [V_{(N+1)} - V_{(N)}] - LSB$

Figure 3. DNL Measurement

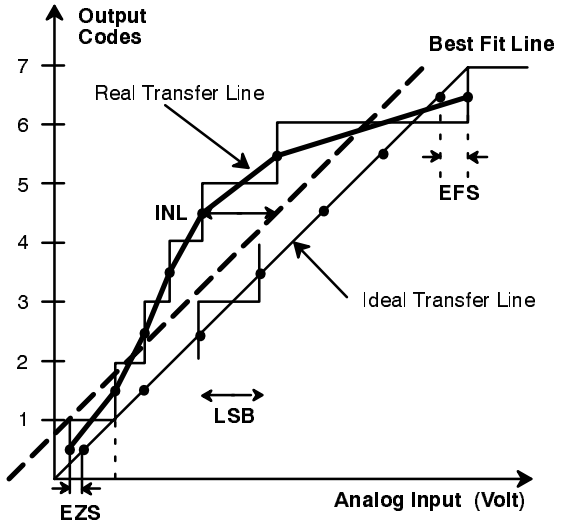


Figure 4. INL Error Calculation

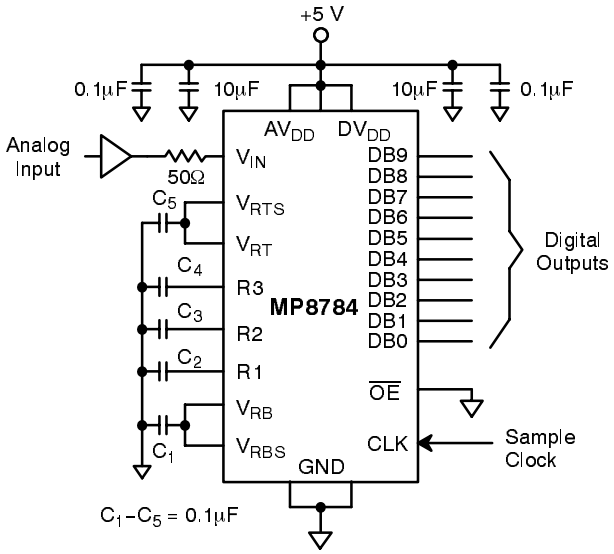


Figure 5. Typical Circuit Connections

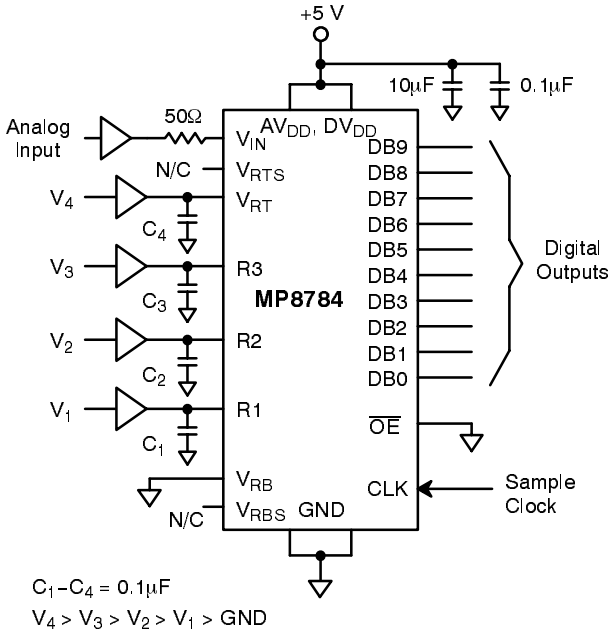


Figure 6. Creating a Piece Wise Linear Transfer Function

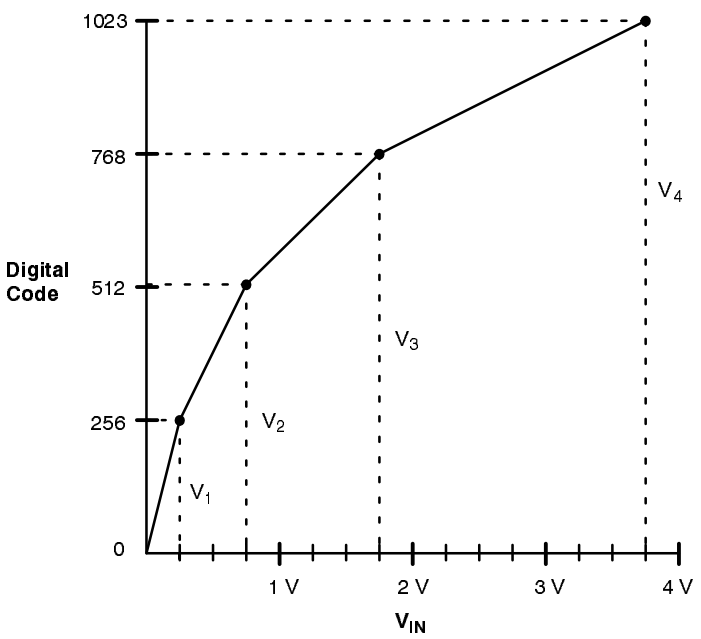


Figure 7. A Piece Wise Linear, Logarithmic Transfer Function

APPLICATION NOTES

Signals should not exceed AV_{DD} or DV_{DD} +0.5V or go below DGND or AGND –0.5V. All pins have internal protection diodes that will protect them from short transients (<100µs) outside the supply range.

AGND and DGND pins are connected internally through the P–substrate. DC voltage differences between these pins will cause undesirable internal substrate currents.

The power supply (AV_{DD}) and reference voltage (V_{RT} & V_{RB}) pins should be decoupled with 0.1µF and 10µF capacitors to AGND, placed as close to the chip as possible.

The digital outputs should not drive long wires or buses. The capacitive coupling and reflections will contribute noise to the conversion.

V_{IN} Analog Input

This part has a switched capacitor type input circuit. This means that the input impedance changes with the phase of the input clock. V_{IN} is sampled at the high to low clock transition. *Figure 8.* shows an equivalent input circuit.

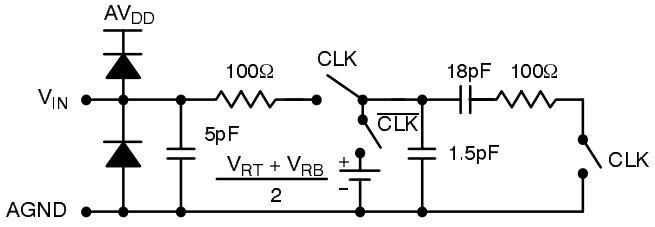


Figure 8. Equivalent Input Circuit

RTS & RBS Internal Bias Resistors

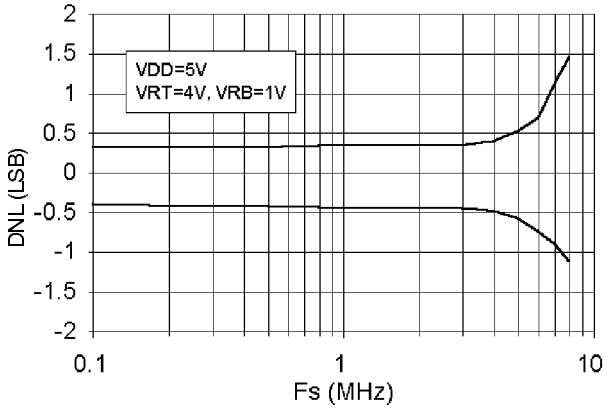
Two matched resistors are provided on the chip. These resistors can be used to generate on chip reference voltages. Each resistor has a value equal to 1/3 of the reference ladder resistor. By connecting RTS to V_{RT}, and connecting RBS to V_{RB}, the reference ladder will be biased to 1 volt at V_{RB} and 4 volts at V_{RT}.

If the internal reference pins V_{RTS} and/or V_{RBS} are not used they should be left unconnected.

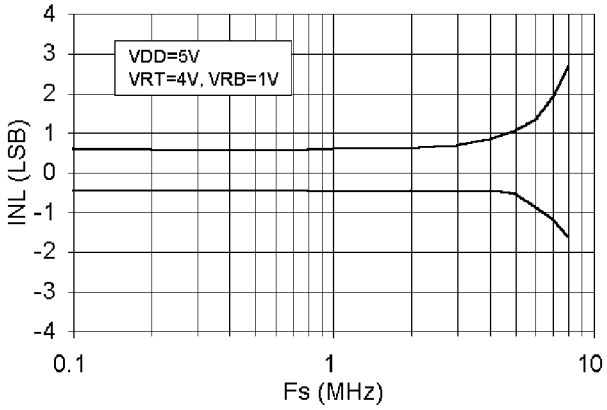
R1 thru R3 Reference Ladder Taps

These taps connect to every quarter point along the reference ladder; R1 is 1/4th up from V_{RB}, R3 is 3/4ths up from V_{RB} (or 1/4th down from V_{RT}). Normally these pins should have 0.1 microfarad capacitors to GND; this helps reduce the INL errors by stabilizing the reference ladder voltages. These taps can also be used to alter the transfer curve of the ADC. A four segment, piecewise linear, custom transfer curve can be designed by connecting voltage sources to these pins.

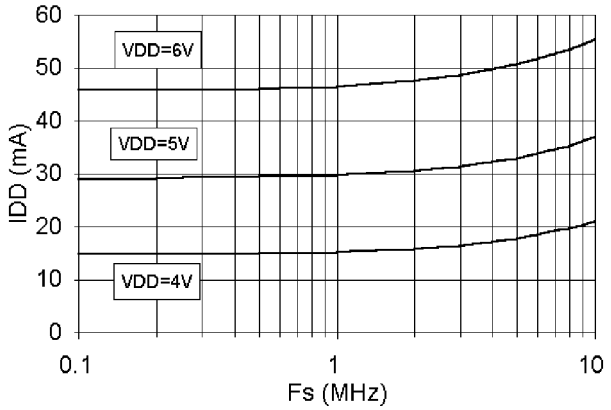
PERFORMANCE CHARACTERISTICS



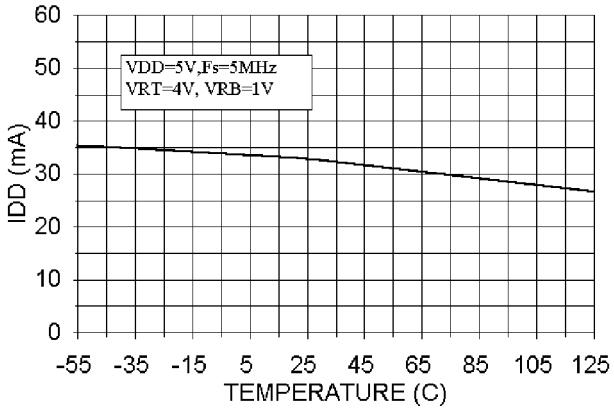
Graph 1. DNL vs. Sampling Frequency



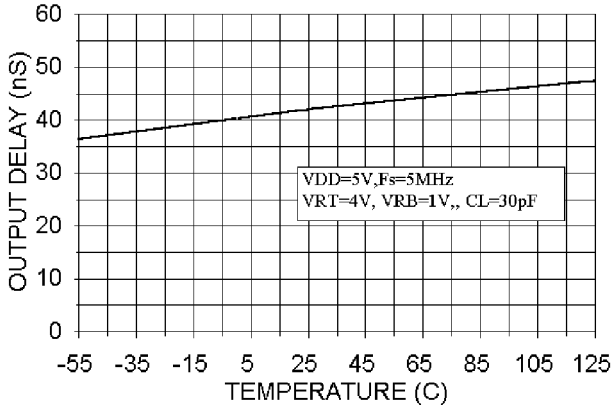
Graph 2. INL vs. Sampling Frequency



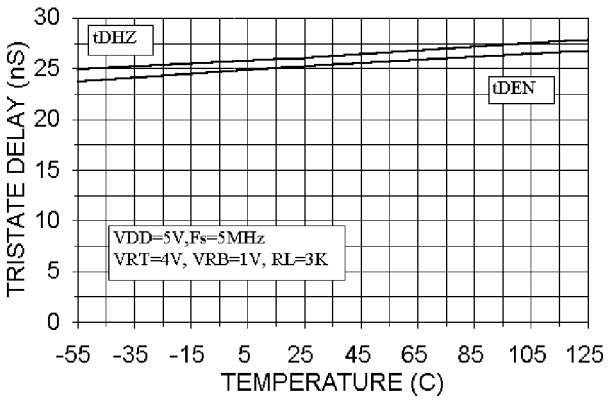
Graph 3. Power Supply Current vs. Sampling Frequency



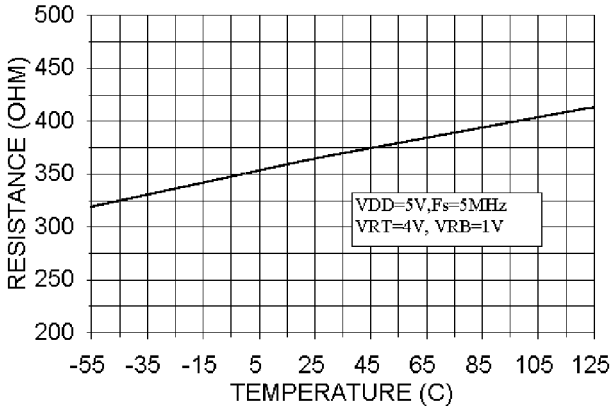
Graph 4. Power Supply Current vs. Temperature



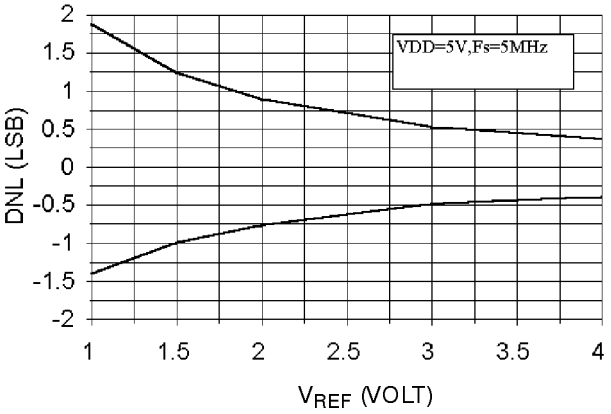
Graph 5. Output Delay vs. Temperature



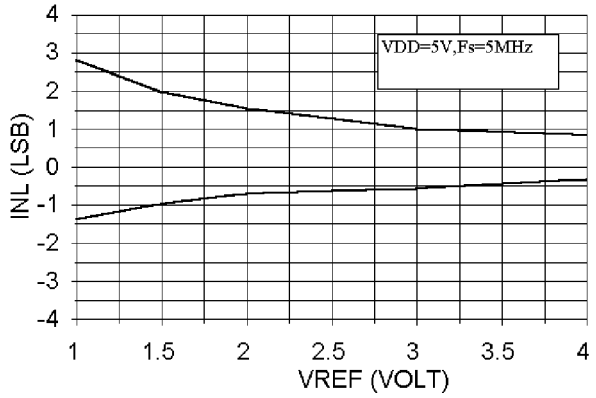
Graph 6. 3-State Delay vs. Temperature



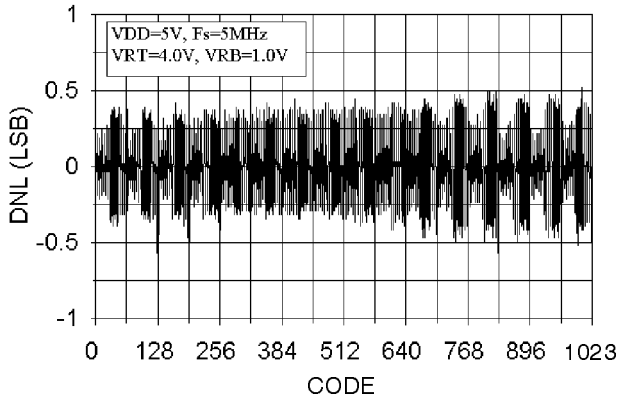
Graph 7. Reference Resistance vs. Temperature



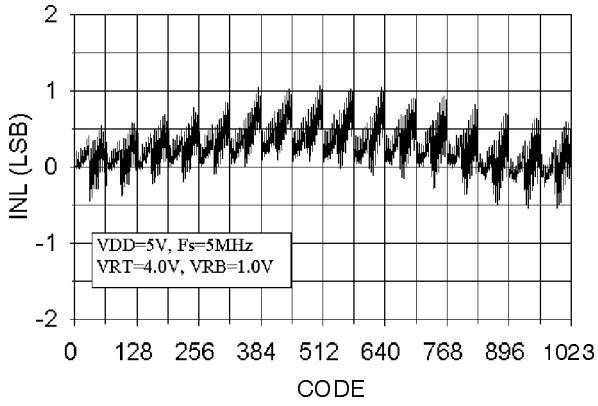
Graph 8. DNL vs. V_{REF}



Graph 9. INL vs. Reference Voltage



Graph 10. DNL Error Plot



Graph 11. INL Error Plot