

MP87L84

Low Voltage CMOS
10-Bit 2 MHz
Analog-to-Digital Converter



FEATURES

- 3.3 V Operation
- 10-Bit Resolution
- 2 MHz Sampling Rate
- $DNL = \pm 1 \text{ LSB}$, $INL = \pm 2 \text{ LSB}$
- Internal S/H Function
- V_{IN} DC Range: 0 V to V_{DD}
- V_{REF} DC Range: 1 V to V_{DD}
- Low Power: 25 mW (typ)
- Three-State Digital Outputs
- Latch-Up Free
- Monotonic. No Missing Codes

APPLICATIONS

March 1998-3

- 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

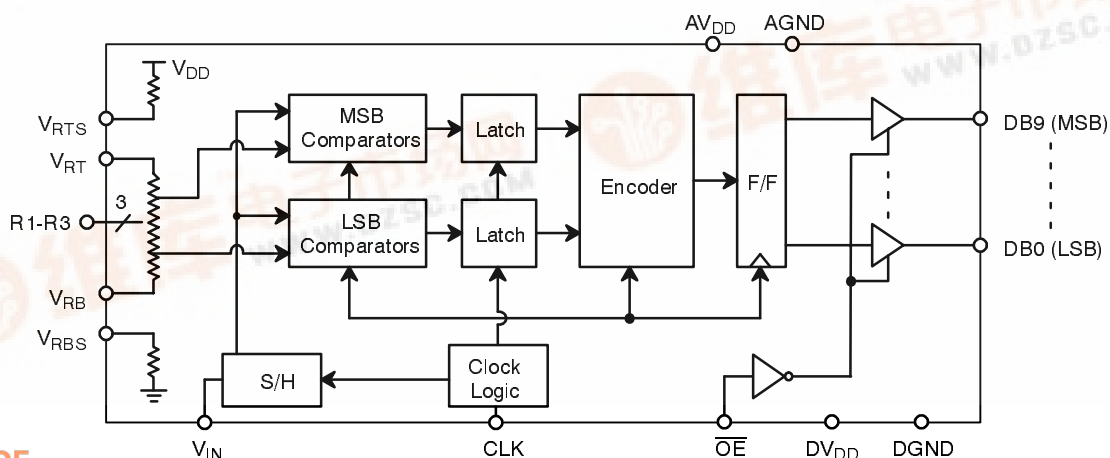
The MP87L84 is a 10-bit, 2 MSPS Analog-to-Digital Converter for applications that require high speed and high accuracy. Designed using an advanced CMOS process, this part offers excellent performance, low power consumption and latch-up free operation.

The MP87L84 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 MP87L84 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. Using a 3V power supply, the internal reference generates 0.6 V at V_{RB} and 2.4 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 3.3 V supply. Power consumption from a 3.3 V supply is typically 25 mW at $F_S=2 \text{ MHz}$.

SIMPLIFIED BLOCK DIAGRAM

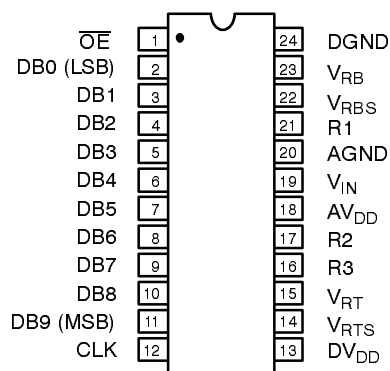


ORDERING INFORMATION

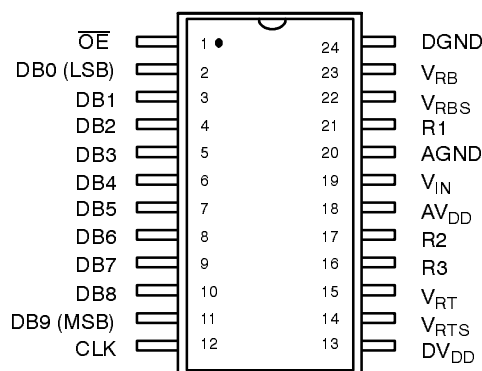
Package Type	Temperature Range	Part No.	DNL (LSB)	INL (LSB)
Plastic Dip	-40 to +85°C	MP87L84AN	±1	2
SOIC	-40 to +85°C	MP87L84AS	±1	2

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: $AV_{DD} = DV_{DD} = 3V$, FS = 2 MHz (50% Duty Cycle),

$V_{RT} = 2.4$, $V_{RB} = 0.6$, $TA = 25^{\circ}C$

Parameter	Symbol	Min	25°C Typ	Max	Units	Test Conditions/Comments
KEY FEATURES						
Resolution		10			Bits	
Maximum Sampling Rate	FS	2			MHz	
ACCURACY (A Grade) ¹						
Differential Non-Linearity	DNL			±1	LSB	Best Fit Line (Max INL – Min INL)/2
Integral Non-Linearity	INL			±2	LSB	
Zero Scale Error	EZS		10		LSB	
Full Scale Error	EFS		6		LSB	
REFERENCE VOLTAGES						
Positive Ref. Voltage ³	V _{RT}			AV _{DD}	V	V _{REF} = V _{RT} – V _{RB}
Negative Ref. Voltage ³	V _{RB}	AGND			V	
Differential Ref. Voltage ³	V _{REF}	1.0		AV _{DD}	V	
Ladder Resistance	R _L		375		Ω	V _{RT} connected to V _{RTS} & V _{RB} connected to V _{RBS}
Ladder Temp. Coefficient ²	R _{TCO}		2000		ppm/°C	
Top Internal Reference	V _{RTS}		4		V	
Bottom Internal Reference	V _{RBS}		1		V	
ANALOG INPUT						
Input Bandwidth (–1 dB) ⁴	BW		5		MHz	
Input Voltage Range	V _{IN}	V _{RB}		V _{RT}	V	
Input Capacitance Sample ⁵	C _{IN}		25		pF	
Input Capacitance Convert ⁵			5		pF	
Aperture Delay ²	t _{AP}		40		ns	
Aperture Uncertainty (Jitter) ²	t _{AJ}		50		ps	
DIGITAL INPUTS						
Logical “1” Voltage	V _{IH}	2.5			V	V _{IN} =DGND to DV _{DD}
Logical “0” Voltage	V _{IL}			0.5	V _I	
DC Leakage Currents ⁶	I _{IN}				μA	
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	500			ns	
Rise & Fall Time ⁸	t _R , t _F		5		ns	
“High” Pulse Width	t _{PWH}		250		ns	
“Low” Pulse Width	t _{PWL}		250		ns	
Duty Cycle			50		%	
DIGITAL OUTPUTS						
Logical “1” Voltage	V _{OH}	2.5			V	C _{OUT} = 15 pF I _{LOAD} = 1 mA I _{LOAD} = 1 mA V _{OUT} =DGND to DV _{DD}
Logical “0” Voltage	V _{OL}			0.5	V	
3-state Leakage	I _{OZ}		10		μA	
Data Valid Delay ²	t _{DL}		75		ns	
Data Enable Delay ²	t _{DEN}		45		ns	
Data 3-state Delay ²	t _{DHZ}		45		ns	

ELECTRICAL CHARACTERISTICS TABLE (CONT'D)

Description	Symbol	25°C			Units	Conditions
		Min	Typ	Max		
POWER SUPPLIES						
Operating Voltage (AV _{DD} , DV _{DD}) ⁹	V _{DD}	3.0	3.3	3.6	V	
Current (AV _{DD} + DV _{DD})	I _{DD}			12	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 GND 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.

Specifications are subject to change without notice

ABSOLUTE MAXIMUM RATINGS (TA = +25°C unless otherwise noted)^{1, 2, 3}

V_{DD} to GND	+5.5 V	Storage Temperature	-65 to +150°C
V_{RT} & V_{RB}	$V_{DD} + 0.5$ to GND - 0.5 V	Package Power Dissipation Rating to 75°C	
V_{IN}	$V_{DD} + 0.5$ to GND - 0.5 V	PDIP, SOIC	1000 mW
All Inputs	$V_{DD} + 0.5$ to GND - 0.5 V	Derating above 75°C	13mW/°C
All Outputs	$V_{DD} + 0.5$ to GND - 0.5 V	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.

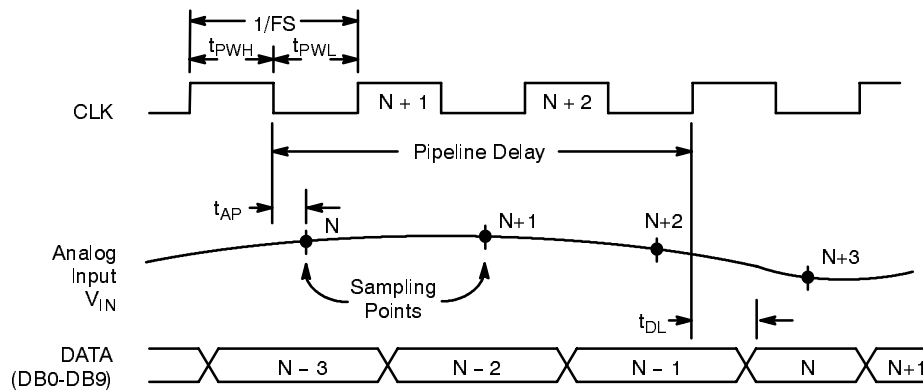


Figure 1. MP87L84 Timing Diagram

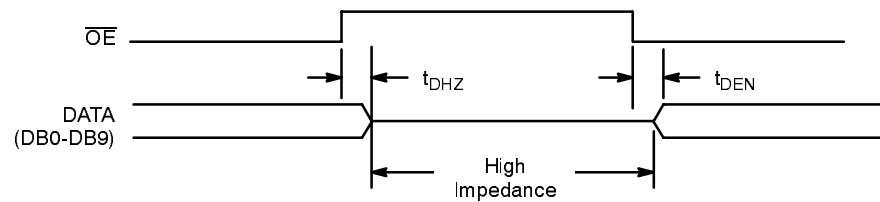


Figure 2. 3-State Timing Diagram

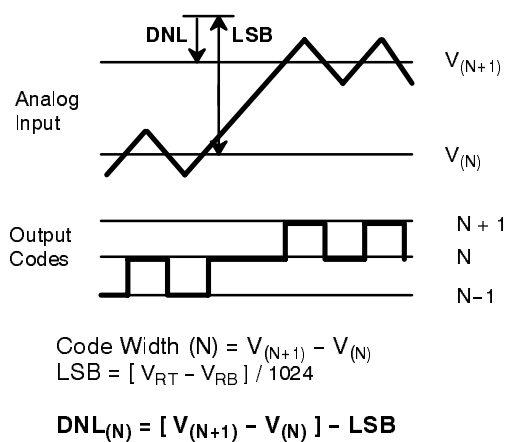


Figure 3. DNL Measurement

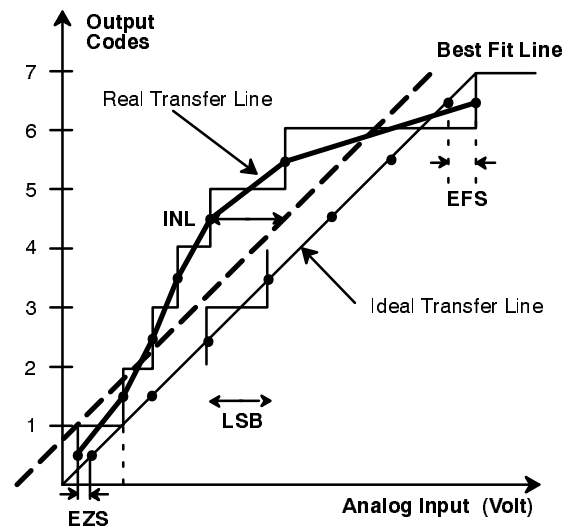


Figure 4. INL Error Calculation

APPLICATION NOTES

Signals should not exceed $AV_{DD} + 0.5V$ or go below AGND $-0.5V$. All pins have internal protection diodes that will protect them from short transients ($< 100\mu s$) 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 $0.1\mu F$ and $10\mu F$ 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.

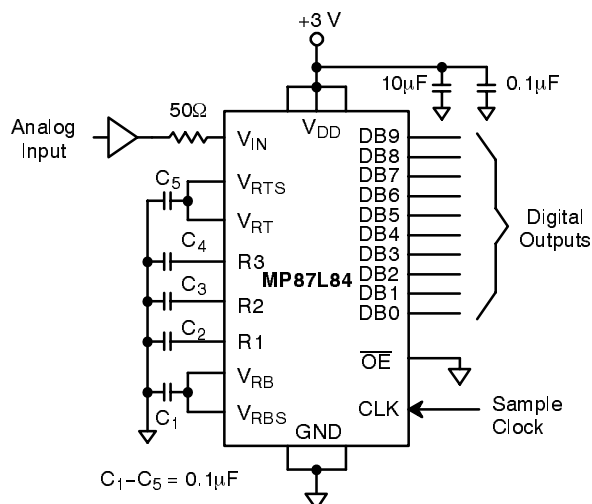


Figure 5. Typical Circuit Connections

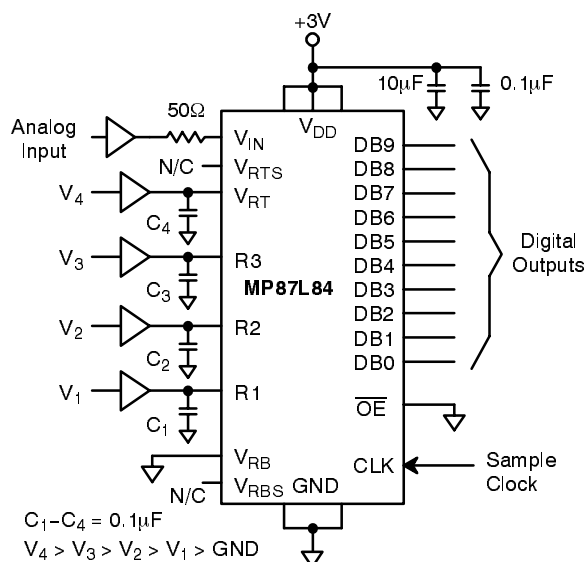


Figure 6. Creating a Piecewise Linear Transfer Function

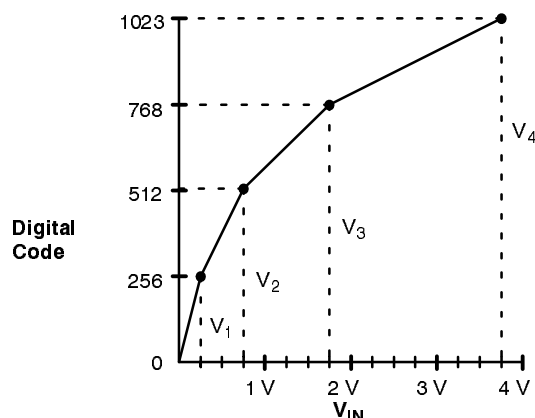


Figure 7. A Piecewise Linear, Logarithmic Transfer Function

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. Figure 8 shows an equivalent input circuit.

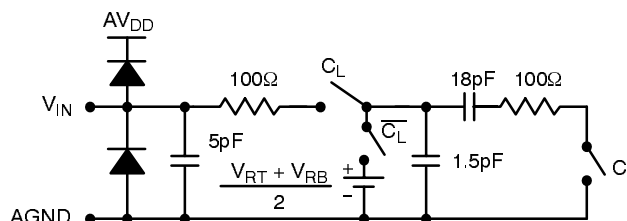


Figure 8. Equivalent Input Circuit

RTS & RBS Internal Bias Resistors

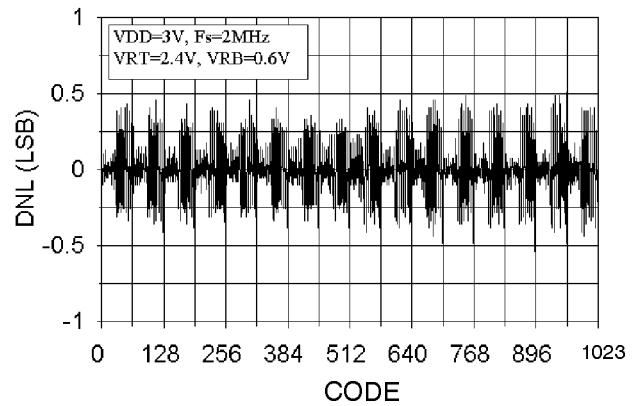
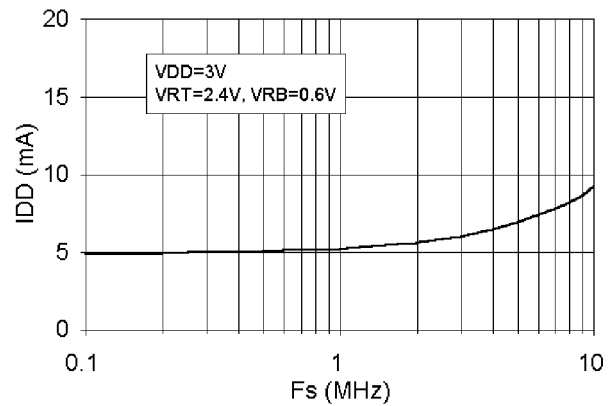
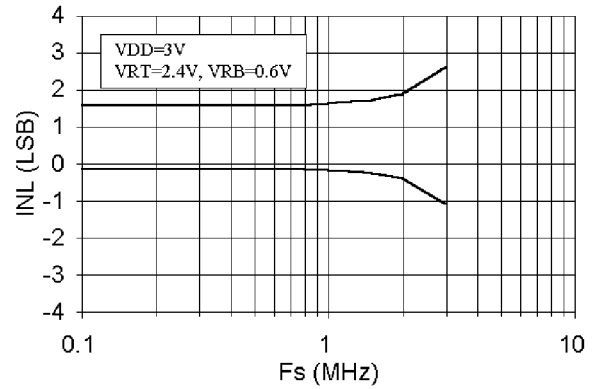
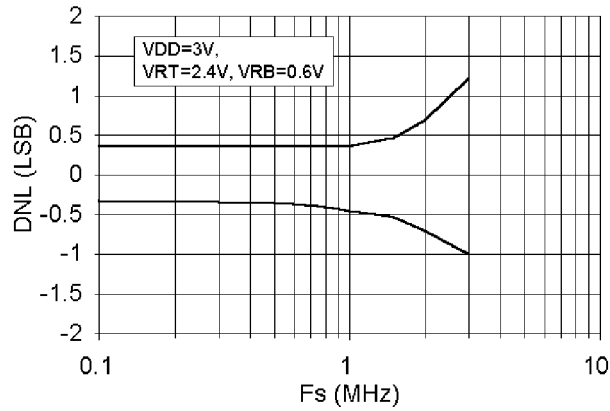
Two matched resistors are provided on the chip. These resistors can be used to generate on chip reference voltages. Each resistor has a value equal to $1/3$ of the reference ladder resistor. By connecting V_{RTS} to V_{RT} , and connecting V_{RBS} to V_{RB} , the reference ladder will be biased to $0.2 * V_{DD}$ at V_{RB} and $0.8 * V_{DD}$ 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

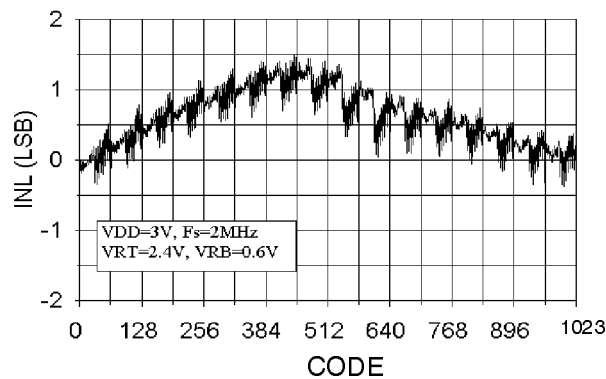
These taps connect to every quarter of the reference ladder; R1 is $1/4$ th up from V_{RB} , R3 is $3/4$ th up from V_{RB} (or $1/4$ th down from V_{RT}). Normally these pins should have 0.1 micro farad capacitors to GND, this helps reduce the INL errors by stabilizing the reference ladder voltages. 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 3. Power Supply Current vs. Sampling Frequency

Graph 4. DNL Error Plot



Graph 5. INL Error Plot