

**FEATURES**

- Pin-compatible with AD9054
- High conversion rate: 200 MSPS
- Less than  $\pm 1/2$  LSB DLE
- 7.16 effective number of bits (ENOB) at 70 MHz
- Single +5 V power supply
- Internal THA and voltage reference
- Low power: 430 mW
- 500 MHz full-power bandwidth
- 1 V<sub>PP</sub> input range
- Single or demuxed TTL output ports
- 44-lead TQFP

**APPLICATIONS**

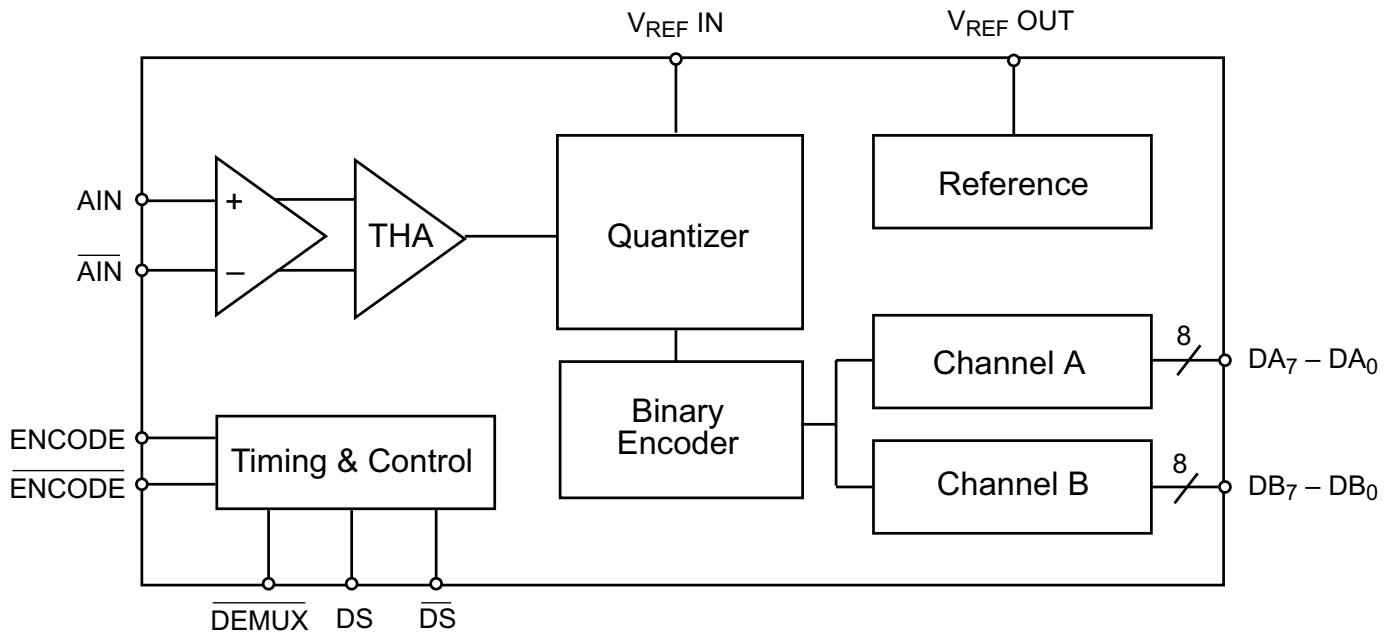
- Digital sampling oscilloscopes (DSO)
- RGB video processing
- Digital communications
- High-speed instrumentation
- Projection display systems

**GENERAL DESCRIPTION**

The SPT7720 is an 8-bit, high-speed, analog-to-digital converter implemented in a 0.5  $\mu$ m BiCMOS process. It utilizes a folding and interpolating architecture that provides both high sample rates and low power. The device comes complete with a high bandwidth track-and-hold amplifier and internal voltage reference.

The SPT7720 digital inputs interface directly to TTL, CMOS or positive ECL (PECL) logic. The digital outputs are user selectable in either single-channel or dual-channel modes. It is a pin-compatible, direct replacement for the AD9054. The SPT7720 is available in a 44-lead TQFP surface mount package over the industrial temperature range of  $-40$  to  $+85$  °C.

**BLOCK DIAGRAM**



# ABSOLUTE MAXIMUM RATINGS (Beyond which damage may occur)<sup>1</sup> 25 °C

## Supply Voltages

V<sub>DD</sub> ..... +6 V

## Input Voltages

Analog Inputs ..... 0.0 to V<sub>DD</sub>

Digital Inputs ..... 0.0 to V<sub>DD</sub>

V<sub>REFL</sub>, V<sub>REFH</sub> ..... 0.0 to V<sub>DD</sub>

## Temperatures

Operating Temperature ..... –40 to +85 °C

Storage Temperature ..... –65 to +125 °C

**Note 1.** Operation at any Absolute Maximum Rating is not implied. See Electrical Specifications for proper nominal applied conditions in typical applications.

## ELECTRICAL SPECIFICATIONS

T<sub>A</sub>=T<sub>MIN</sub> to T<sub>MAX</sub>, V<sub>DD</sub>=+5.0 V, external reference, f<sub>S</sub>=200 MSPS, input amplitude = –1 dBFS, unless otherwise noted

PARAMETERS	TEST CONDITIONS	TEST LEVEL	MIN	SPT7720 TYP	MAX	UNITS
<b>DC Accuracy</b>						
Differential Linearity Error (DLE)	+25 °C	I		±0.41	±0.75	LSB
	–40 °C to +85 °C	V		±1.0	±1.0	LSB
Integral Linearity Error (ILE)	+25 °C	I		±0.56	±1.0	LSB
	–40 °C to +85 °C	V		±0.9	±1.2	LSB
No Missing Codes		VI		Guaranteed		
Gain Error	+25 °C	I		±1.06	±1.08	%FS
Gain Tempco		V		0		ppm/°C
<b>Switching Performance</b>						
Encode Pulsewidth High	+25 °C	IV	2.125	15		ns
Encode Pulsewidth Low	+25 °C	IV	2.125	15		ns
Aperture Delay (t <sub>A</sub> )	+25 °C	V		0.57		ns
Aperture Uncertainty (Jitter) & Noise	+25 °C	V		4.5		ps rms
Data Sync Setup Time (t <sub>S<sub>DS</sub></sub> )	+25 °C	IV	0			ns
Data Sync Hold Time (t <sub>H<sub>DS</sub></sub> )	+25 °C	IV	0.5			ns
Data Sync Pulsewidth Time (t <sub>P<sub>WDS</sub></sub> )	+25 °C	IV	2.0			ns
Output Valid Time (t <sub>V</sub> )		IV	4.4	5.7		ns
Output Prop. Delay (t <sub>PD</sub> )		IV		6.7	8.0	ns
<b>Dynamic Performance</b>						
Transient Response	+25 °C	V		1.5		ns
Overvoltage Recovery Time	+25 °C	V		1.5		ns
Signal-to-Noise Ratio (SNR) (without harmonics)						
f <sub>IN</sub> = 19.7 MHz	+25 °C	V		47		dB
f <sub>IN</sub> = 19.7 MHz	–40 °C to +85 °C	V		47		dB
f <sub>IN</sub> = 70.1 MHz	+25 °C	I	44	46.3		dB
f <sub>IN</sub> = 70.1 MHz	–40 °C to +85 °C	V		45.8		dB
Signal-to-Noise Ratio and Distortion (SINAD)						
f <sub>IN</sub> = 19.7 MHz	+25 °C	V		47		dB
f <sub>IN</sub> = 19.7 MHz	–40 °C to +85 °C	V		43		dB
f <sub>IN</sub> = 70.1 MHz	+25 °C	I	43	44.9		dB
f <sub>IN</sub> = 70.1 MHz	–40 °C to +85 °C	V		44.5		dB
2nd Harmonic Distortion						
f <sub>IN</sub> = 19.7 MHz	+25 °C	V		–59		dBc
f <sub>IN</sub> = 70.1 MHz	+25 °C	V		–55.4		dBc
3rd Harmonic Distortion						
f <sub>IN</sub> = 19.7 MHz	+25 °C	V		–58		dBc
f <sub>IN</sub> = 70.1 MHz	+25 °C	V		–56.4		dBc
Total Harmonic Distortion (THD)						
f <sub>IN</sub> = 70.1 MHz	+25 °C	I		–50.9	–46.0	dBc
f <sub>IN</sub> = 70.1 MHz	–40 to +85 °C	V		–48.3		dBc
Effective Number of Bits (ENOB)						
f <sub>IN</sub> = 70.1 MHz	+25 °C	I	6.9	7.16		Bits
f <sub>IN</sub> = 70.1 MHz	–40 to +85 °C	V	6.5			Bits

# ELECTRICAL SPECIFICATIONS

$T_A = T_{MIN}$  to  $T_{MAX}$ ,  $V_{DD} = +5.0$  V, external reference,  $f_S = 200$  MSPS, input amplitude =  $-1$  dBFS, unless otherwise noted

PARAMETERS	TEST CONDITIONS	TEST LEVEL	MIN	SPT7720 TYP	MAX	UNITS
<b>Analog Input</b>						
Input Voltage Range (differential)		V		$\pm 0.5$		V
Compliance Range		V	1.8		3.2	V
Input Offset Voltage	+25 °C	I		$\pm 4$	$\pm 16$	mV
Input Offset Voltage	-40 °C to +85 °C	V		$\pm 8$	$\pm 19$	mV
Input Resistance	+25 °C	V	36	62		k $\Omega$
Input Capacitance		V		4		pF
Input Bias Current	+25 °C	I		11	50	$\mu$ A
Input Bias Current	-40 °C to +85 °C	V			75	$\mu$ A
Full Power Bandwidth		V		500		MHz
<b>Reference Output Voltage</b>						
Temperature Coefficient		VI	2.4	2.5	2.6	V
		V		110		ppm/°C
<b>Differential Digital Inputs</b>						
High Level Current	-40 to +85 °C >1.5 V differential	V		500	625	$\mu$ A
Low Level Current	-40 to +85 °C >1.5 V differential	V		500	625	$\mu$ A
Input Capacitance		V		3		pF
<b>Differential Inputs</b>						
Differential Signal Amplitude		IV	400			mV
High Input Voltage		IV	1.5		$V_{DD}$	V
Low Input Voltage		IV	0		$V_{DD}-0.4$	V
Common-Mode Input Voltage		IV	1.5			V
<b>Demux Input</b>						
High Input Voltage		VI	2.0		$V_{DD}$	V
Low Input Voltage		VI	0		0.8	V
<b>Digital Outputs</b>						
High Output Voltage	Source 800 $\mu$ A	VI	2.4	3.9		V
Low Output Voltage	Sink 1.6 mA	VI		0.8	0.4	V
Output Coding				Binary		
<b>Power Supply</b>						
$V_{DD}$ Supply Current	-40 to +85 °C	VI		86	111	mA
Power Dissipation		VI		430	555	mW
Power Supply Sensitivity	+25 °C	IV		0.005	0.015	V/V

## TEST LEVEL CODES

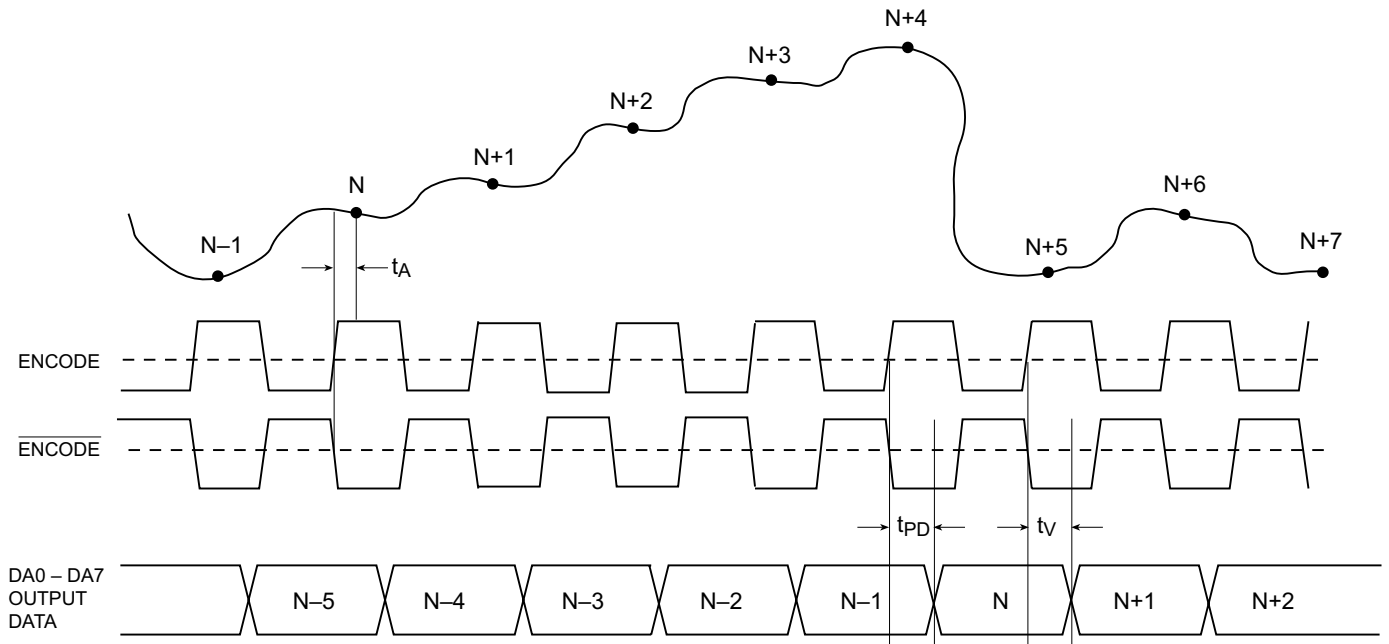
All electrical characteristics are subject to the following conditions:

All parameters having min/max specifications are guaranteed. The Test Level column indicates the specific device testing actually performed during production and Quality Assurance inspection. Any blank section in the data column indicates that the specification is not tested at the specified condition.

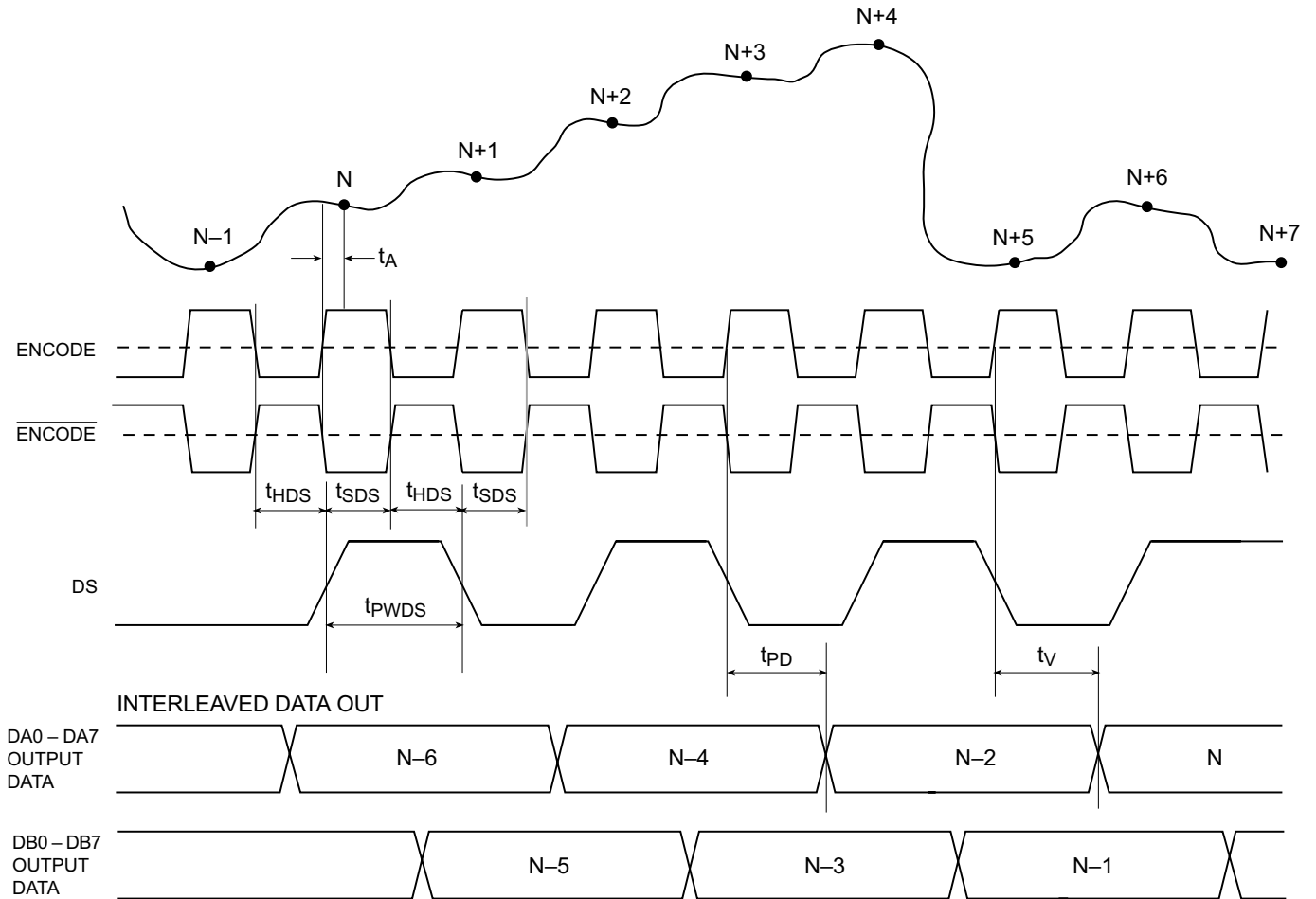
## TEST LEVEL TEST PROCEDURE

I	100% production tested at the specified temperature.
II	100% production tested at $T_A = +25$ °C, and sample tested at the specified temperatures.
III	QA sample tested only at the specified temperatures.
IV	Parameter is guaranteed (but not tested) by design and characterization data.
V	Parameter is a typical value for information purposes only.
VI	100% production tested at $T_A = +25$ °C. Parameter is guaranteed over specified temperature range.

**Figure 1 – Timing Diagram – Single-Channel Mode**

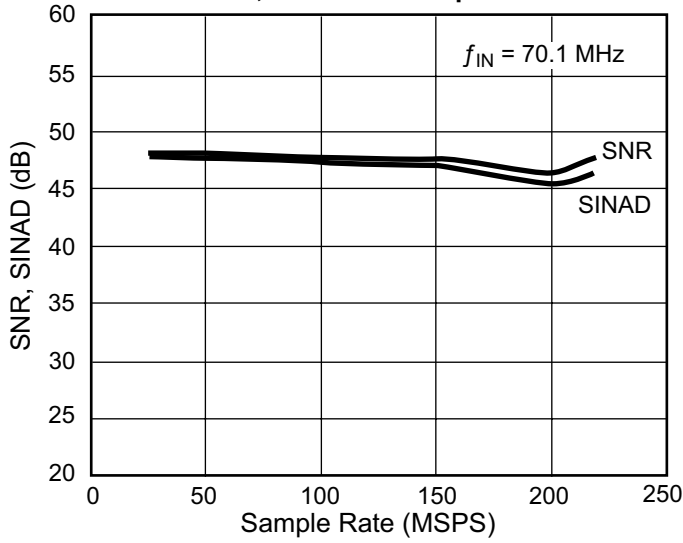


**Figure 2 – Timing Diagram – Dual-Channel Mode**

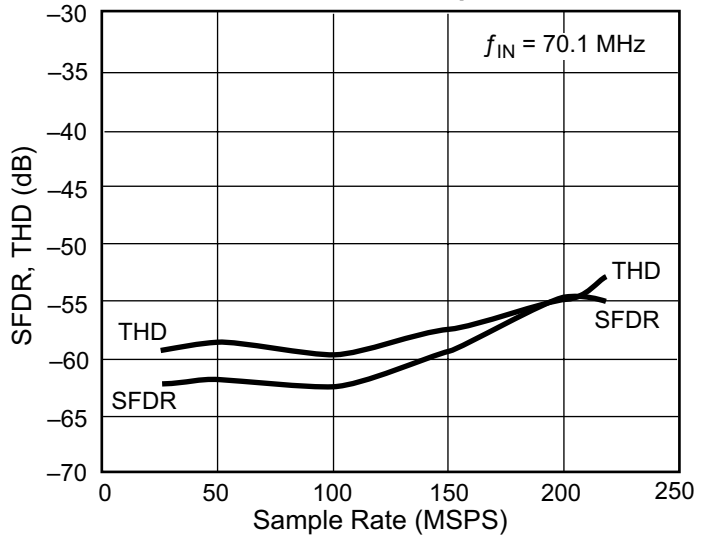


# TYPICAL PERFORMANCE CHARACTERISTICS

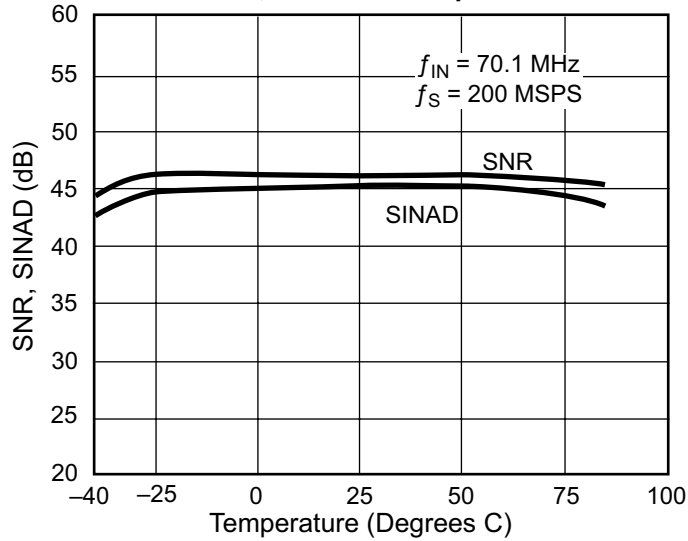
## SNR, SINAD vs Sample Rate



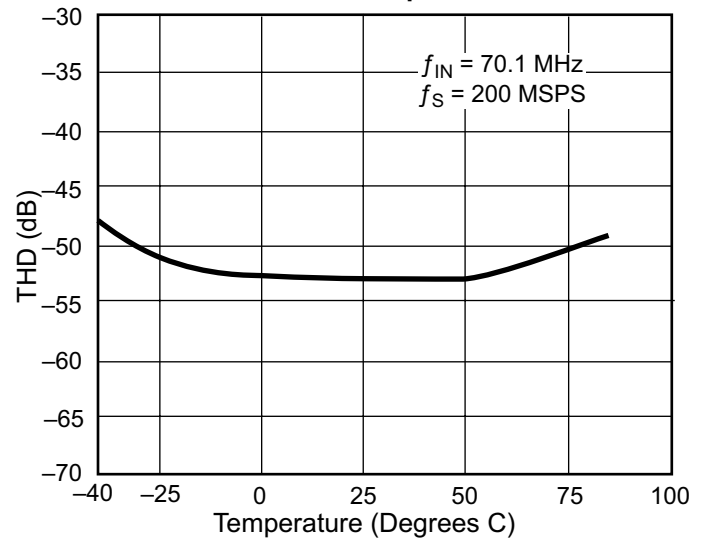
## SFDR, THD vs Sample Rate



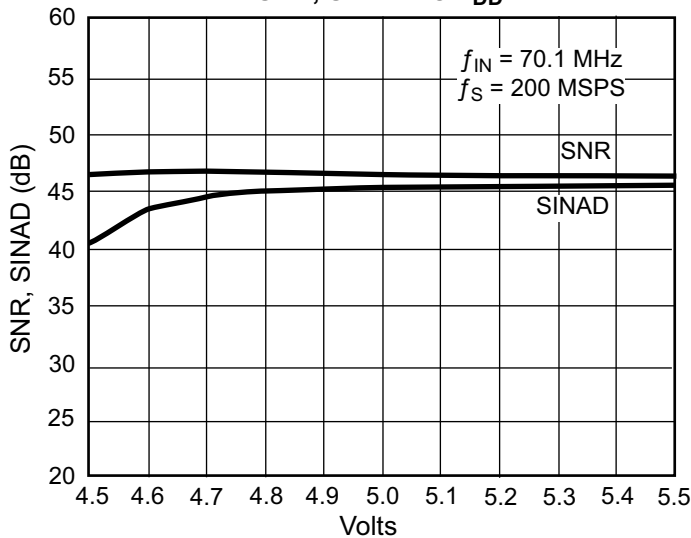
## SNR, SINAD vs Temperature



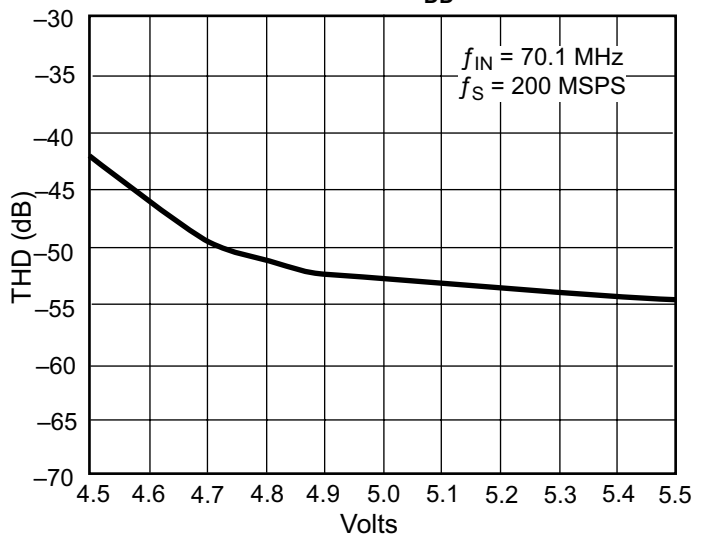
## THD vs Temperature



## SNR, SINAD vs V<sub>DD</sub>

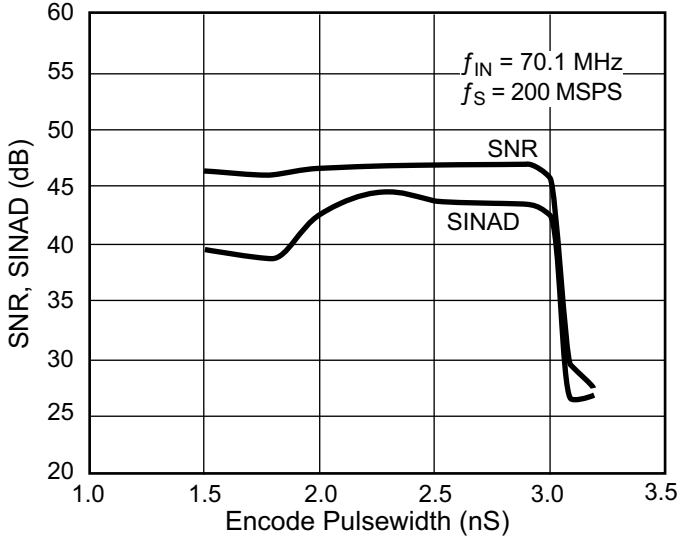


## THD vs V<sub>DD</sub>

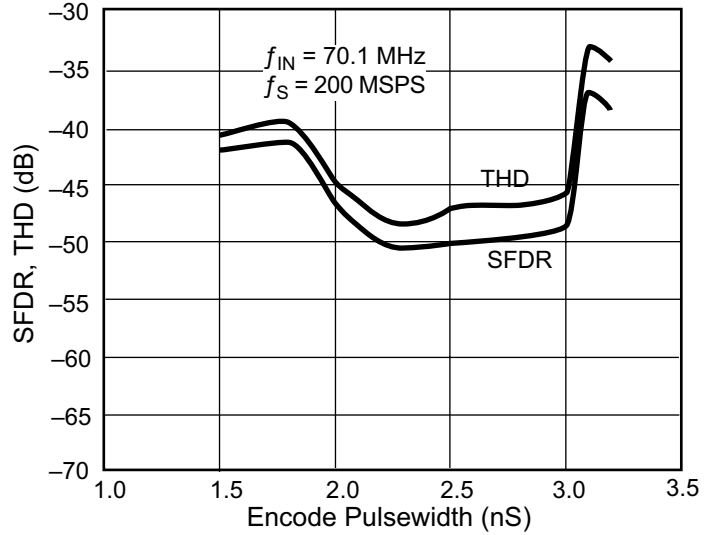


# TYPICAL PERFORMANCE CHARACTERISTICS

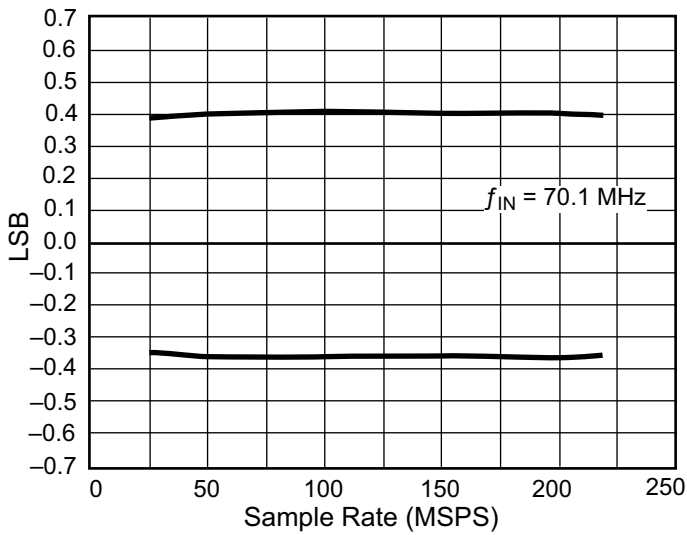
## SNR, SINAD vs Encode Pulsewidth



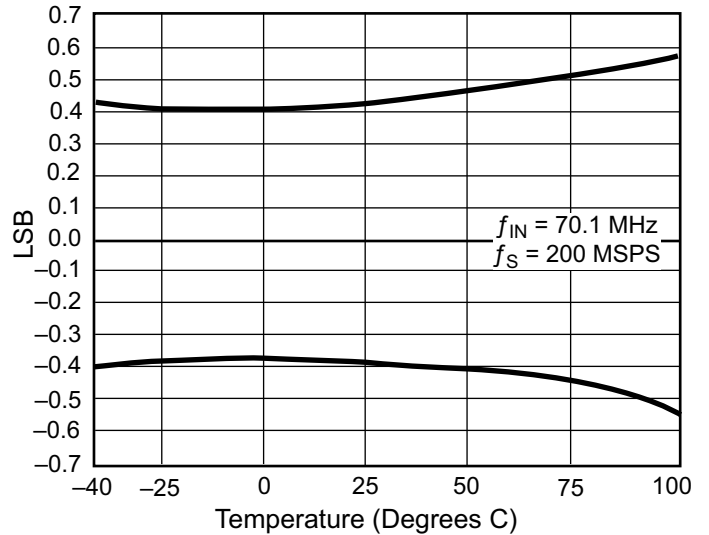
## SFDR, THD vs Encode Pulsewidth



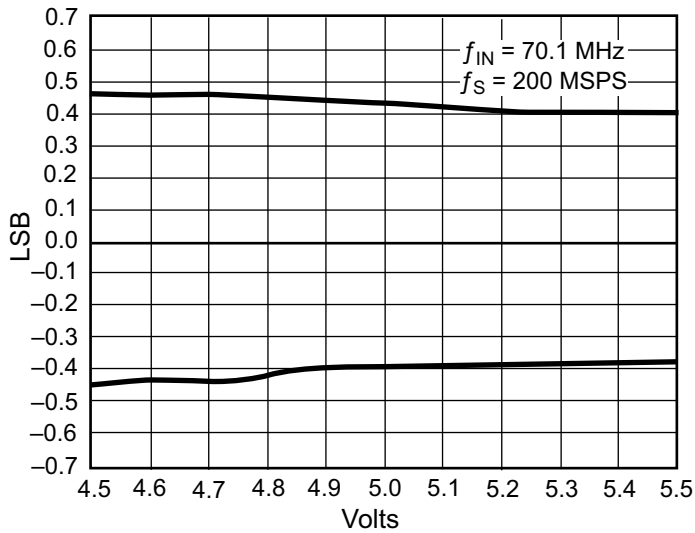
## DLE vs Sample Rate



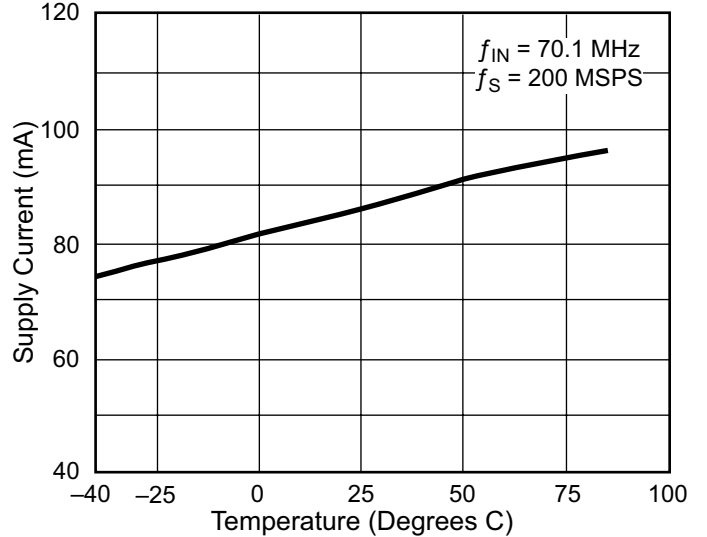
## DLE vs Temperature



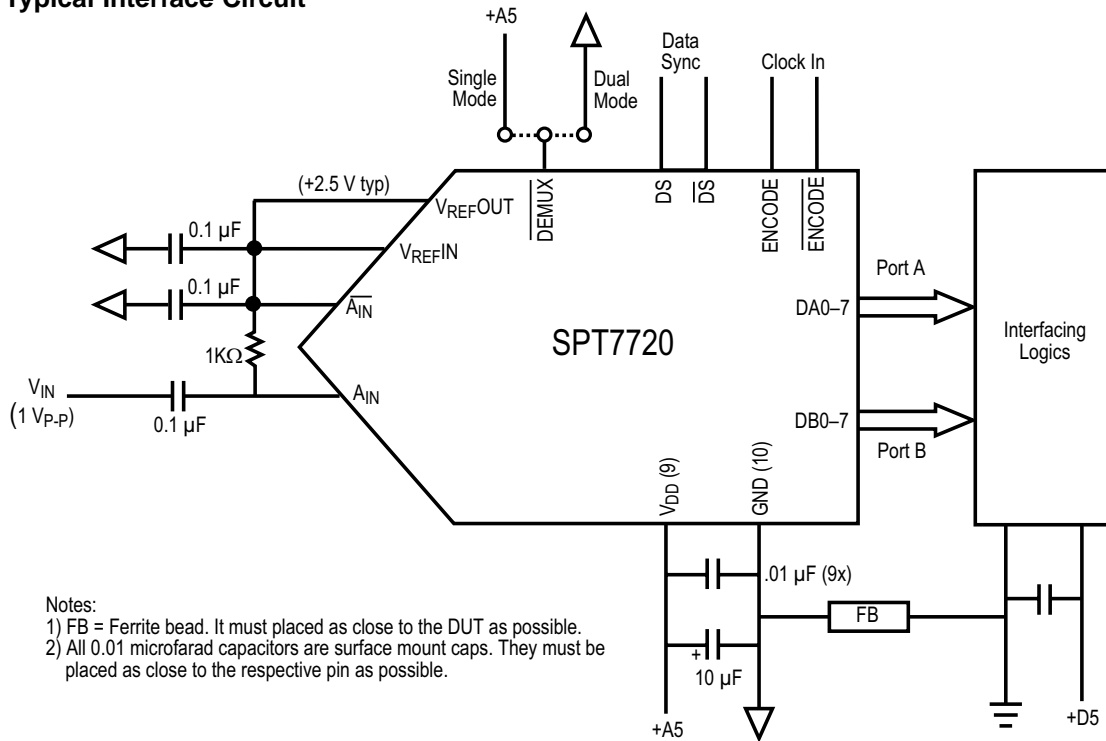
## DLE vs $V_{DD}$



## Supply Current vs Temperature



**Figure 3 – Typical Interface Circuit**



## TYPICAL INTERFACE CIRCUIT

Very few external components are required to achieve the stated device performance. Figure 3 shows the typical interface requirements when using the SPT7720 in normal circuit operation. The following sections provide descriptions of the major functions and outline performance criteria to consider for achieving the optimal device performance.

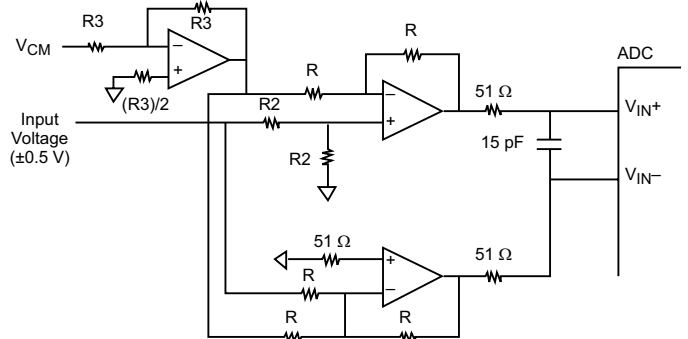
### ANALOG INPUT

The input of the SPT7720 can be configured in various ways depending on whether a single-ended or differential input is desired.

The AC-coupled input is most conveniently implemented using a transformer with a center-tapped secondary winding. The center tap is connected to the  $V_{CM}$  pin as shown in figure 3. To obtain low distortion, it is important that the selected transformer does not exhibit core saturation at the full-scale voltage. Proper termination of the input is important for input signal purity. A small capacitor across the input attenuates kickback noise from the internal track-and-hold.

Figure 4 illustrates a solution (based on operational amplifiers) that can be used if a DC-coupled single-ended input is desired. It is very important to select op amps with a high open-loop gain, a bandwidth high enough so as not to impair the performance of the ADC, low THD, and high SNR.

**Figure 4 – DC-Coupled Single-Ended to Differential Conversion** (power supplies and bypassing are not shown)



### INPUT PROTECTION

All I/O pads are protected with an on-chip protection circuit. This circuit provides ESD robustness and prevents latchup under severe discharge conditions without degrading analog transmission times.

### POWER SUPPLIES AND GROUNDING

The SPT7720 is operated from a single power supply in the range of 4.75 to 5.25 volts. Normal operation is suggested to be 5.0 volts. All power supply pins should be bypassed as close to the package as possible.

## REFERENCES

To save on parts count, design time, and PC board real estate, the SPT7720 utilizes an internal reference. No other external components are required to implement this feature.

## VOLTAGE REFERENCE CIRCUIT

The SPT7720 has an on-board voltage reference circuit ( $V_{REF}$ ). It is 2.5 volts and is capable of driving 50  $\mu$ A loads typically. The circuit is commonly used to drive the center tap of the RF transformer in fully differential applications. For single-ended applications, this output can be used to provide the level shifting required for the single-to-differential converter conversion circuit.

## ENCODE INPUT

The ENCODE input on the SPT7720 can be driven by either a single-ended or differential clock circuit and can handle TTL, PECL, and CMOS signals. When operating at high sample rates it is important to keep the pulse width of the duty signal as close to 50% as possible. For TTL/CMOS single-ended ENCODE inputs, the rise time of the signal also becomes an important consideration. The ENCODE input is 300  $\Omega$  into a bipolar differential pair. ENCODE is internally biased to 1.5 V with a Thevenin equivalent of 5.25 k $\Omega$ .

## DIGITAL INPUTS

The DS input is 35  $\Omega$  into one side of a differential pair. There is a two-diode clamp from DS to  $\overline{DS}$  in both directions.  $\overline{DS}$  is biased to 1.5 V with a Thevenin equivalent of 5.25 k $\Omega$ .

The  $\overline{DEMUX}$  pin is input to one side of a CMOS differential pair. The other side is internally biased to 1.5 V and does not connect to the outside.

## DIGITAL OUTPUTS

The output circuitry of the SPT7720 has been designed to be able to support two separate output modes. The demuxed (double-wide) mode supports interleaved data output. The single-channel mode is not demuxed and can support direct output at speeds up to 100 MSPS.

The output format is straight binary (table I).

Table I – Output Data Format

Analog Input	Output Code D7–D0
+FS	1111 1111
+FS – 1/2 LSB	1111 111 $\emptyset$
+1/2 FS	$\emptyset\emptyset\emptyset\emptyset \emptyset\emptyset\emptyset\emptyset$
–FS + 1/2 LSB	0000 000 $\emptyset$
–FS	0000 0000

$\emptyset$  indicates the flickering bit between logic 0 and 1

The data output mode is set using the  $\overline{DEMUX}$  input (pin 42). Table II describes the mode switching options.

Table II – Output Data Modes

Output Mode	$\overline{DEMUX}$
Interleaved Dual Channel Output	0
Single Channel Data Output (Bank A only 100 MSPS max)	1

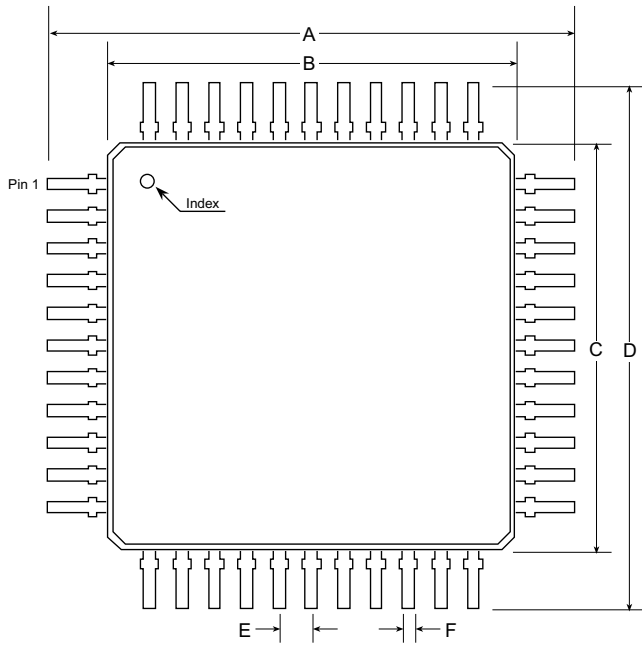
## EVALUATION BOARD

The EB7720 evaluation board is available to aid designers in demonstrating the full performance of the SPT7720. This board includes a clock driver and reset circuit, adjustable references and common mode, a single-ended to differential input buffer and a single-ended to differential transformer (1:1). An application note (AN7720) describing the operation of this board, as well as information on the testing of the SPT7720, is also available. Contact the factory for price and availability of the EB7720.

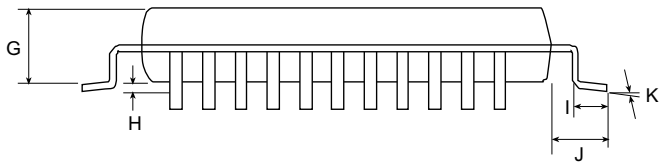


# PACKAGE OUTLINE

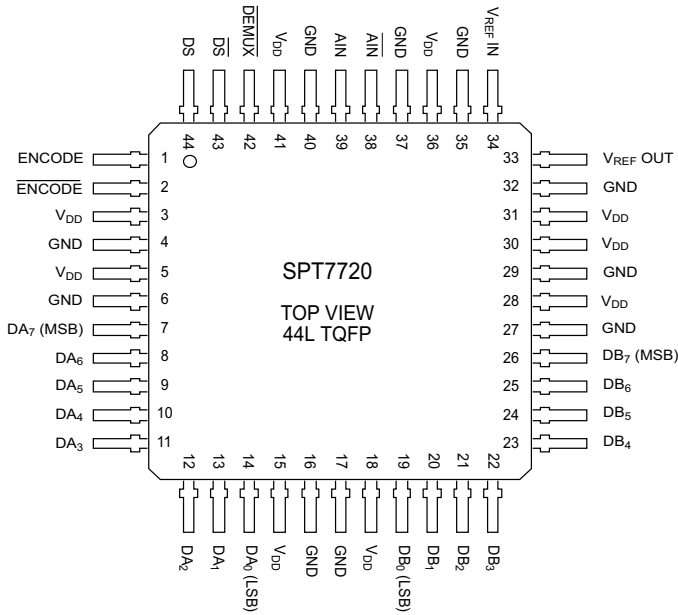
## 44-Lead TQFP



SYMBOL	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.472 Typ		12.00 Typ	
B	0.394 Typ		10.00 Typ	
C	0.394 Typ		10.00 Typ	
D	0.472 Typ		12.00 Typ	
E	0.031 Typ		0.80 Typ	
F	0.012	0.018	0.300	0.45
G	0.053	0.057	1.35	1.45
H	0.002	0.006	0.05	0.15
I	0.018	0.030	0.450	0.750
J	0.039 Typ		1.00 Typ	
K	0-7°		0-7°	



## PIN ASSIGNMENTS



## PIN FUNCTIONS

Pin Name	Description
AIN, AIN	Differential Input Pins
ENCODE	Differential Clock Input
ENCODE	
V <sub>DD</sub>	Power Supply
GND	Ground
DA <sub>0</sub> –DA <sub>7</sub>	Digital Outputs, Channel A
DB <sub>0</sub> –DB <sub>7</sub>	Digital Outputs, Channel B
V <sub>REF OUT</sub>	Reference Output Voltage
V <sub>REF IN</sub>	Reference Input Voltage, High
DEMUX	Format Select: LOW = Dual-Channel Mode, HIGH = Single-Channel Mode
DS, DS	Data Sync and Data Sync Complement – Aligns Output Channels in Dual-Channel Mode

## ORDERING INFORMATION

PART NUMBER	TEMPERATURE RANGE	PACKAGE
SPT7720SIT	–40 to +85 °C	44L TQFP

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