

**FOR NEW DESIGNS, INTERSIL RECOMMENDS  
THE HI5767/4CB OR HI5746KCB**

November 1998

File Number 3950.7

**10-Bit, 40 MSPS A/D Converter**

The HI5703 is a monolithic, 10-bit, analog-to-digital converter fabricated in Intersil's BiCMOS process. It is designed for high speed applications where wide bandwidth and low power consumption are essential. Its 40 MSPS speed is made possible by a fully differential pipeline architecture with an internal sample and hold.

The HI5703 has excellent dynamic performance while consuming only 400mW power at 40 MSPS. Data output latches are provided which present valid data to the output bus with a latency of 7 clock cycles. It is pin-to-pin compatible with the HI5702.

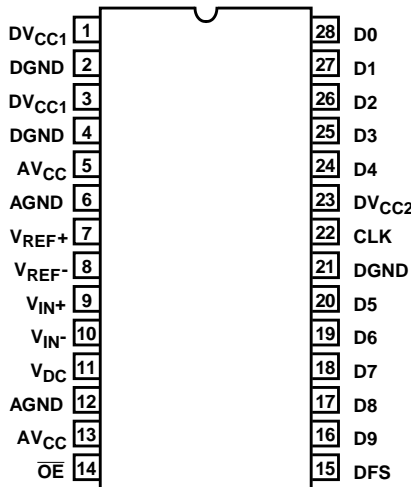
For lower power consumption or internal reference, please refer to the HI5746 or HI5767.

**Ordering Information**

| PART NUMBER | TEMP. RANGE (°C) | PACKAGE          | PKG. NO. |
|-------------|------------------|------------------|----------|
| HI5703KCB   | 0 to 70          | 28 Ld SOIC (W)   | M28.3    |
| HI5703EVAL  | 25               | Evaluation Board |          |

**Pinout**

**HI5703  
(SOIC)  
TOP VIEW**



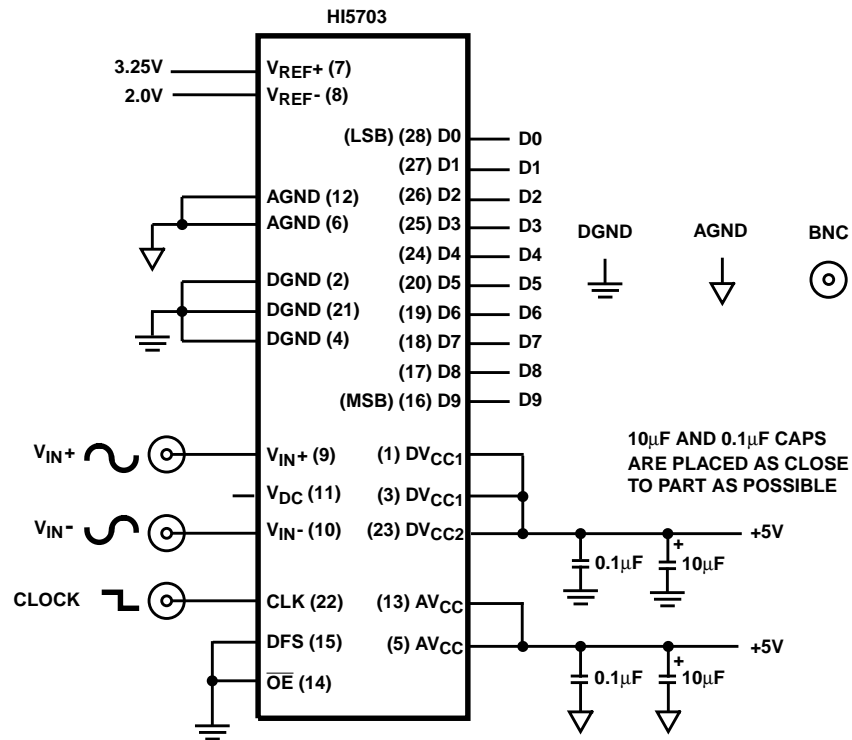
**Features**

- Sampling Rate . . . . . 40 MSPS
- 8.55 Bits Guaranteed at  $f_{IN} = 10\text{MHz}$
- Low Power
- Wide Full Power Input Bandwidth. . . . . 250MHz
- On Chip Sample and Hold
- Fully Differential or Single-Ended Analog Input
- Single Supply Voltage. . . . . +5V
- TTL Compatible Interface
- 3.3V Digital Outputs Available

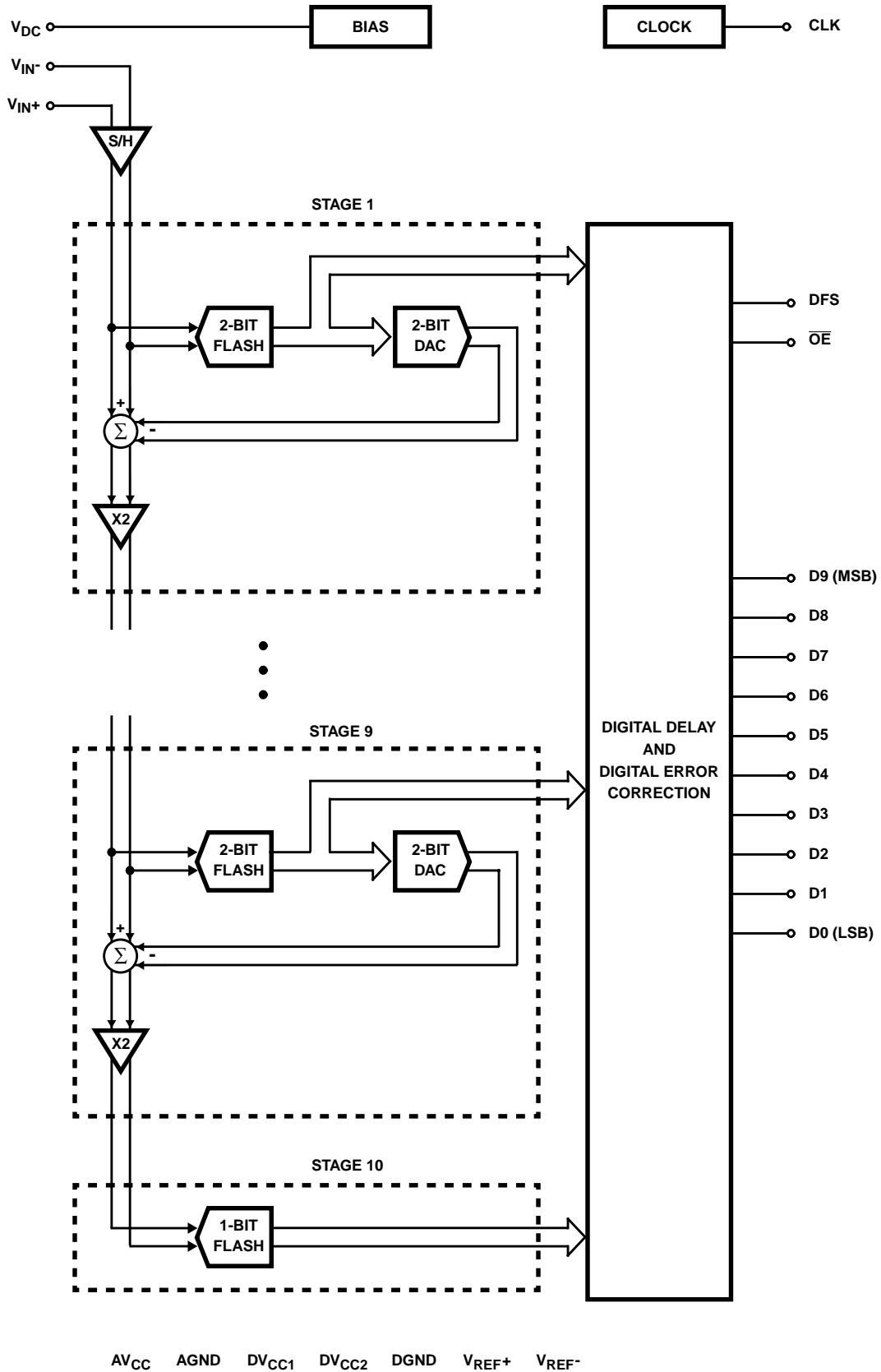
**Applications**

- Professional Video Digitizing
- Medical Imaging
- Digital Communication Systems
- High Speed Data Acquisition
- Additional Reference Documents
  - AN9534 Using the HI5703 Evaluation Board
  - AN9413 Driving the Analog Input of the HI5702
  - AN9214 Using Intersil High Speed A/D Converters

## Typical Application Schematic



# Functional Block Diagram



## Absolute Maximum Ratings $T_A = 25^\circ\text{C}$

|  |                   |
|--|-------------------|
| Supply Voltage, $AV_{CC}$ or $DV_{CC}$ to AGND or DGND | +6V               |
| DGND to AGND   | 0.3V              |
| Digital I/O Pins                                       | DGND to $DV_{CC}$ |
| Analog I/O Pins  | AGND to $AV_{CC}$ |

## Operating Conditions

Temperature Range, HI5703KCB . . . . .  $0^\circ\text{C}$  to  $70^\circ\text{C}$

*CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.*

### NOTE:

- $\theta_{JA}$  is measured with the component mounted on an evaluation PC board in free air.

## Thermal Information

|  |  |
|--|--|
| Thermal Resistance (Typical, Note 1)     | $\theta_{JA}$ ( $^\circ\text{C}/\text{W}$ )    |
| SOIC Package                             | 70   |
| Maximum Junction Temperature             | $150^\circ\text{C}$                            |
| Maximum Storage Temperature Range        | $-65^\circ\text{C}$ to $150^\circ\text{C}$     |
| Maximum Lead Temperature (Soldering 10s) | $300^\circ\text{C}$<br>(SOIC - Lead Tips Only) |

## Electrical Specifications $AV_{CC} = DV_{CC1} = DV_{CC2} = +5.0\text{V}$ ; $V_{REF+} = 3.25\text{V}$ ; $V_{REF-} = 2.0\text{V}$ ; $f_S = 36$ MSPS at 50% Duty Cycle; $C_L = 20\text{pF}$ ; $T_A = 25^\circ\text{C}$ ; Differential Analog Input; Unless Otherwise Specified

| PARAMETER   | TEST CONDITION          | MIN  | TYP       | MAX       | UNITS |
|---|-------------------------|------|-----------|-----------|-------|
| <b>ACCURACY</b>   |                         |      |           |           |       |
| Resolution  |                         | 10   | -         | -         | Bits  |
| Integral Linearity Error, INL   | $f_{IN} = \text{DC}$    | -    | $\pm 1$   | $\pm 2.0$ | LSB   |
| Differential Linearity Error, DNL<br>(Guaranteed No Missing Codes)  | $f_{IN} = \text{DC}$    | -    | $\pm 0.5$ | $\pm 1$   | LSB   |
| Offset Error, $V_{OS}$  | $f_{IN} = \text{DC}$    | -    | 4         | -         | LSB   |
| Full Scale Error, FSE   | $f_{IN} = \text{DC}$    | -    | 1         | -         | LSB   |
| <b>DYNAMIC CHARACTERISTICS</b>  |                         |      |           |           |       |
| Minimum Conversion Rate   | No Missing Codes        | -    | 0.5       | 1         | MSPS  |
| Maximum Conversion Rate   | No Missing Codes        | 40   | -         | -         | MSPS  |
| Effective Number of Bits, ENOB  | $f_{IN} = 1\text{MHz}$  | -    | 9.2       | -         | Bits  |
|   | $f_{IN} = 5\text{MHz}$  | -    | 9.2       | -         | Bits  |
|   | $f_{IN} = 10\text{MHz}$ | 8.55 | 8.9       | -         | Bits  |
| Signal to Noise and Distortion Ratio, SINAD<br>$= \frac{\text{RMS Signal}}{\text{RMS Noise} + \text{Distortion}}$ | $f_{IN} = 1\text{MHz}$  | -    | 57        | -         | dB    |
|   | $f_{IN} = 5\text{MHz}$  | -    | 57        | -         | dB    |
|   | $f_{IN} = 10\text{MHz}$ | 53.2 | 55        | -         | dB    |
| Signal to Noise Ratio, SNR<br>$= \frac{\text{RMS Signal}}{\text{RMS Noise}}$                                      | $f_{IN} = 1\text{MHz}$  | -    | 58        | -         | dB    |
|   | $f_{IN} = 5\text{MHz}$  | -    | 58        | -         | dB    |
|   | $f_{IN} = 10\text{MHz}$ | 53.2 | 57        | -         | dB    |
| Total Harmonic Distortion, THD  | $f_{IN} = 1\text{MHz}$  | -    | -64       | -         | dBc   |
|   | $f_{IN} = 5\text{MHz}$  | -    | -63       | -         | dBc   |
|   | $f_{IN} = 10\text{MHz}$ | -    | -60       | -         | dBc   |
| 2nd Harmonic Distortion   | $f_{IN} = 1\text{MHz}$  | -    | -75       | -         | dBc   |
|   | $f_{IN} = 5\text{MHz}$  | -    | -75       | -         | dBc   |
|   | $f_{IN} = 10\text{MHz}$ | -    | -73       | -         | dBc   |
| 3rd Harmonic Distortion   | $f_{IN} = 1\text{MHz}$  | -    | -66       | -         | dBc   |
|   | $f_{IN} = 5\text{MHz}$  | -    | -64       | -         | dBc   |
|   | $f_{IN} = 10\text{MHz}$ | -    | -63       | -         | dBc   |

**Electrical Specifications**  $V_{CC} = DV_{CC1} = DV_{CC2} = +5.0V$ ;  $V_{REF+} = 3.25V$ ;  $V_{REF-} = 2.0V$ ;  $f_S = 36$  MSPS at 50% Duty Cycle;  $C_L = 20pF$ ;  $T_A = 25^\circ C$ ; Differential Analog Input; Unless Otherwise Specified **(Continued)**

| PARAMETER  | TEST CONDITION                     | MIN   | TYP        | MAX      | UNITS     |
|--|------------------------------------|-------|------------|----------|-----------|
| Spurious Free Dynamic Range, SFDR  | $f_{IN} = 1MHz$                    | -     | 66         | -        | dBc       |
|  | $f_{IN} = 5MHz$                    | -     | 64         | -        | dBc       |
|  | $f_{IN} = 10MHz$                   | 54    | 63         | -        | dBc       |
| Intermodulation Distortion, IMD  | $f_1 = 1MHz, f_2 = 1.02MHz$        | -     | -59        | -        | dBc       |
| Differential Gain Error  | $f_S = 17.72MHz, 6$ Step, Mod Ramp | -     | 0.5        | -        | %         |
| Differential Phase Error   | $f_S = 17.72MHz, 6$ Step, Mod Ramp | -     | 0.1        | -        | Degree    |
| Transient Response   |                                    | -     | 1          | -        | Cycle     |
| Over-Voltage Recovery  | 0.2V Overdrive                     | -     | 1          | -        | Cycle     |
| <b>ANALOG INPUT</b>  |                                    |       |            |          |           |
| Maximum Peak-to-Peak Differential Analog Input Range ( $V_{IN+} - V_{IN-}$ ) |                                    | -     | $\pm 1.25$ | -        | V         |
| Maximum Peak-to-Peak Single-Ended Analog Input Range                         |                                    | -     | 2.5        | -        | V         |
| Analog Input Resistance, $R_{IN}$  | (Note 3)                           | -     | 1          | -        | $M\Omega$ |
| Analog Input Capacitance, $C_{IN}$   |                                    | -     | 7          | -        | pF        |
| Analog Input Bias Current, $I_{B+}$ or $I_{B-}$                              | (Note 3)                           | -10   | -          | +10      | $\mu A$   |
| Differential Analog Input Bias Current $I_{B\ DIFF} = (I_{B+} - I_{B-})$     |                                    | -     | $\pm 0.5$  | -        | $\mu A$   |
| Analog Input Common Mode Voltage Range ( $(V_{IN+} + V_{IN-}) / 2$ )         | Differential Mode (Note 1)         | 0.625 | -          | 4.375    | V         |
| Full Power Input Bandwidth (FPBW)  |                                    | -     | 250        | -        | MHz       |
| <b>REFERENCE INPUT</b>   |                                    |       |            |          |           |
| Total Reference Resistance, $R_L$  |                                    | 300   | 400        | 500      | $\Omega$  |
| Reference Current  |                                    | 2.5   | 3.125      | 4.2      | mA        |
| Positive Reference Voltage Input, $V_{REF+}$                                 | (Note 2)                           | -     | 3.25       | 3.3      | V         |
| Negative Reference Voltage Input, $V_{REF-}$                                 | (Note 2)                           | 1.95  | 2.0        | -        | V         |
| Reference Common Mode Voltage ( $(V_{REF+} + V_{REF-}) / 2$ )                | (Note 2)                           | 2.575 | 2.625      | 2.675    | V         |
| <b>DC BIAS VOLTAGE</b>   |                                    |       |            |          |           |
| DC Bias Voltage Output, $V_{DC}$   |                                    | -     | 2.8        | -        | V         |
| Max Output Current   |                                    | -     | -          | 1        | mA        |
| <b>DIGITAL INPUTS</b>  |                                    |       |            |          |           |
| Input Logic High Voltage, $V_{IH}$   |                                    | 2.0   | -          | -        | V         |
| Input Logic Low Voltage, $V_{IL}$  |                                    | -     | -          | 0.8      | V         |
| Input Logic High Current, $I_{IH}$   | $V_{IH} = 5V$                      | -     | -          | 10.0     | $\mu A$   |
| Input Logic Low Current, $I_{IL}$  | $V_{IL} = 0V$                      | -     | -          | 10.0     | $\mu A$   |
| Input Capacitance, $C_{IN}$  |                                    | -     | 7          | -        | pF        |
| <b>DIGITAL OUTPUTS</b>   |                                    |       |            |          |           |
| Output Logic Sink Current, $I_{OL}$  | $V_O = 0.4V; DV_{CC2} = 5V$        | 1.6   | -          | -        | mA        |
| Output Logic Source Current, $I_{OH}$  | $V_O = 2.4V; DV_{CC2} = 5V$        | -0.2  | -          | -        | mA        |
| Output Three-State Leakage Current, $I_{OZ}$                                 | $V_O = 0/5V; DV_{CC2} = 5V$        | -     | $\pm 1$    | $\pm 10$ | $\mu A$   |
| Output Logic Sink Current, $I_{OL}$  | $V_O = 0.4V; DV_{CC2} = 3.3V$      | 1.6   | -          | -        | mA        |
| Output Logic Source Current, $I_{OH}$  | $V_O = 2.4V; DV_{CC2} = 3.3V$      | -0.2  | -          | -        | mA        |
| Output Three-State Leakage Current, $I_{OZ}$                                 | $V_O = 0/3.3V; DV_{CC2} = 3.3V$    | -     | $\pm 1$    | $\pm 10$ | $\mu A$   |
| Output Capacitance, $C_{OUT}$  |                                    | -     | 5          | -        | pF        |

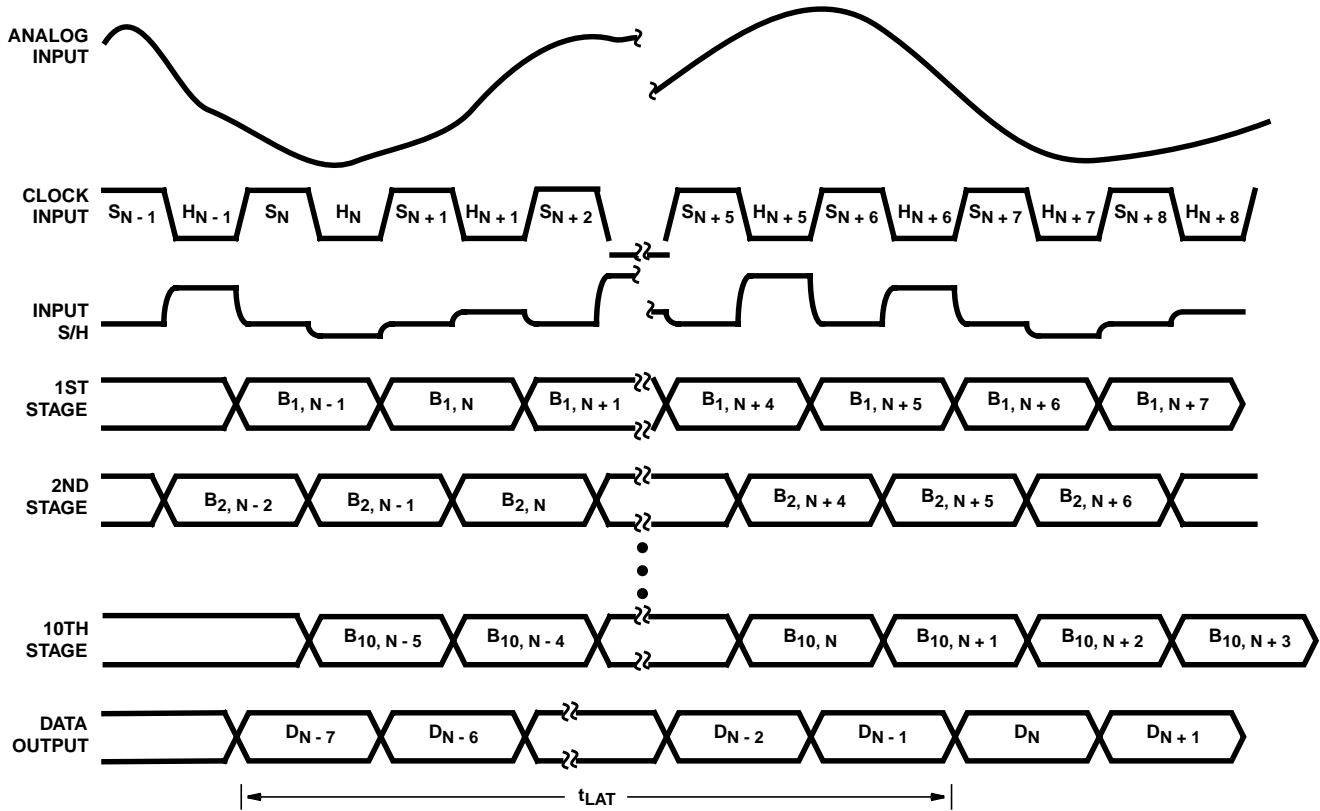
**Electrical Specifications**  $AV_{CC} = DV_{CC1} = DV_{CC2} = +5.0V$ ;  $V_{REF+} = 3.25V$ ;  $V_{REF-} = 2.0V$ ;  $f_S = 36$  MSPS at 50% Duty Cycle;  $C_L = 20pF$ ;  $T_A = 25^{\circ}C$ ; Differential Analog Input; Unless Otherwise Specified **(Continued)**

| PARAMETER                                  | TEST CONDITION  | MIN    | TYP       | MAX    | UNITS  |
|--|---|--------|-----------|--------|--------|
| <b>TIMING CHARACTERISTICS</b>              |   |        |           |        |        |
| Aperture Delay, $t_{AP}$                   |   | -      | 5         | -      | ns     |
| Aperture Jitter, $t_{AJ}$                  |   | -      | 5         | -      | ps     |
| Data Output Delay, $t_{OD}$                |   | -      | 7         | -      | ns     |
|  | $AV_{CC} = DV_{CC1} = 5V \pm 10\%$ ,<br>$DV_{CC2} = 3.3V \pm 5\%$ ,<br>$0^{\circ}C \leq T_A \leq 70^{\circ}C$ | 5      | 7         | 18     | ns     |
| Data Output Hold, $t_H$                    |   | -      | 4         | -      | ns     |
| Data Output Enable Time, $t_{EN}$          |   | -      | 7         | -      | ns     |
| Data Output Enable Time, $t_{DIS}$         |   | -      | 7         | -      | ns     |
| Clock Pulse Width (Low)                    | 40 MSPS Clock   | 11.875 | 12.5      | 13.125 | ns     |
| Clock Pulse Width (High)                   | 40 MSPS Clock   | 11.875 | 12.5      | 13.125 | ns     |
| Data Latency, $t_{LAT}$                    | For a Valid Sample (Note 2)   | -      | -         | 7      | Cycles |
| Power-Up Initialization                    | Data Invalid Time (Note 2)  | -      | -         | 20     | Cycles |
| <b>POWER SUPPLY CHARACTERISTICS</b>        |   |        |           |        |        |
| Analog Supply Voltage, $AV_{CC}$           |   | 4.75   | 5.0       | 5.25   | V      |
| Digital Supply Voltage, $DV_{CC1}$         |   | 4.75   | 5.0       | 5.25   | V      |
| Digital Output Supply Voltage, $DV_{CC2}$  | At 3.30V  | 3.135  | 3.3       | 3.465  | V      |
|  | At 5.0V   | 4.75   | 5.0       | 5.25   | V      |
| Total Supply Current, $I_{CC}$             | $V_{IN+} - V_{IN-} = +1.25V$ and DFS = "0"  | -      | 80        | -      | mA     |
| Analog Supply Current, $AI_{CC}$           | $V_{IN+} - V_{IN-} = +1.25V$ and DFS = "0"  | -      | 48        | -      | mA     |
| Digital Supply Current, $DI_{CC1}$         | $V_{IN+} - V_{IN-} = +1.25V$ and DFS = "0"  | -      | 30        | -      | mA     |
| Digital Output Supply Current, $DI_{CC2}$  | $V_{IN+} - V_{IN-} = +1.25V$ and DFS = "0"  | -      | 2         | -      | mA     |
| Power Dissipation                          | $V_{IN+} - V_{IN-} = +1.25V$ and DFS = "0"  | -      | 400       | -      | mW     |
| Offset Error Sensitivity, $\Delta V_{OS}$  | $AV_{CC}$ or $DV_{CC} = 5V \pm 5\%$   | -      | $\pm 1.5$ | -      | LSB    |
| Full Scale Error Sensitivity, $\Delta FSE$ | $AV_{CC}$ or $DV_{CC} = 5V \pm 5\%$   | -      | $\pm 0.2$ | -      | LSB    |

NOTES:

- Parameter guaranteed by design or characterization and not production tested.
- With the clock low and DC input.

## Timing Waveforms



### NOTES:

4.  $S_N$ : N-th sampling period.
5.  $H_N$ : N-th holding period.
6.  $B_{M,N}$ : M-th stage digital output corresponding to N-th sampled input.
7.  $D_N$ : Final data output corresponding to N-th sampled input.

FIGURE 1. HI5703 INTERNAL CIRCUIT TIMING

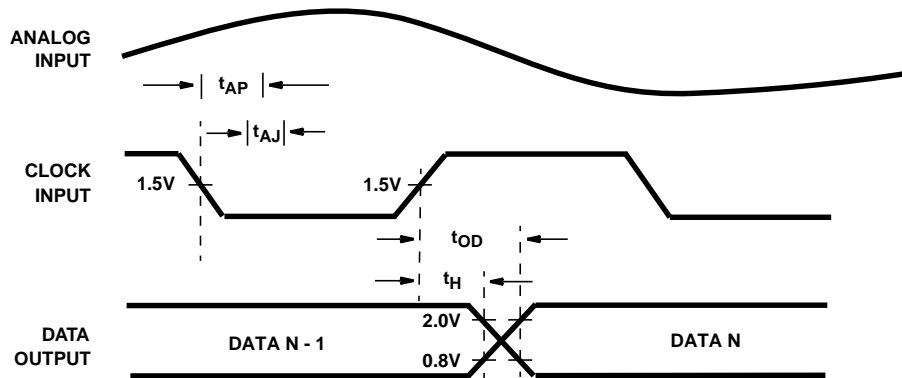


FIGURE 2. INPUT-TO-OUTPUT TIMING

## Typical Performance Curves

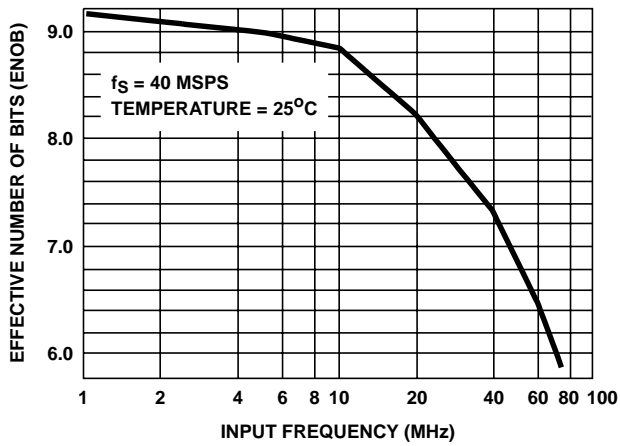
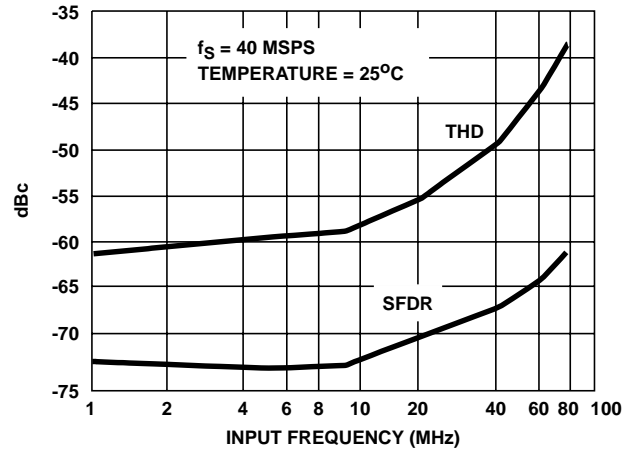


FIGURE 3. EFFECTIVE NUMBER OF BITS (ENOB) vs INPUT FREQUENCY



NOTE: SFDR depicted here does not include any harmonic distortion.

FIGURE 4. TOTAL HARMONIC DISTORTION (THD) AND SPURIOUS FREE DYNAMIC RANGE (SFDR) vs INPUT FREQUENCY

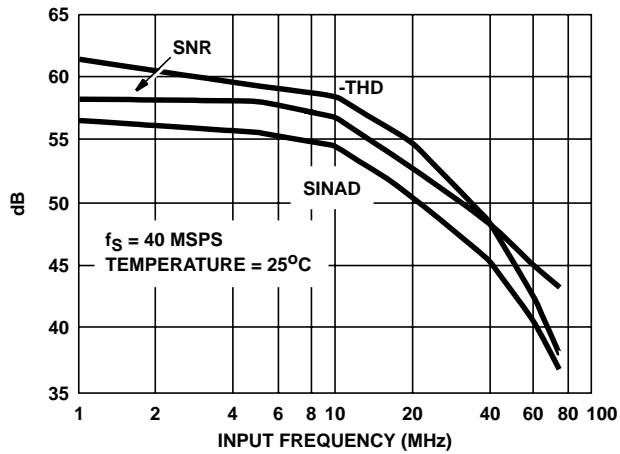


FIGURE 5. SINAD, SNR, AND -THD vs INPUT FREQUENCY

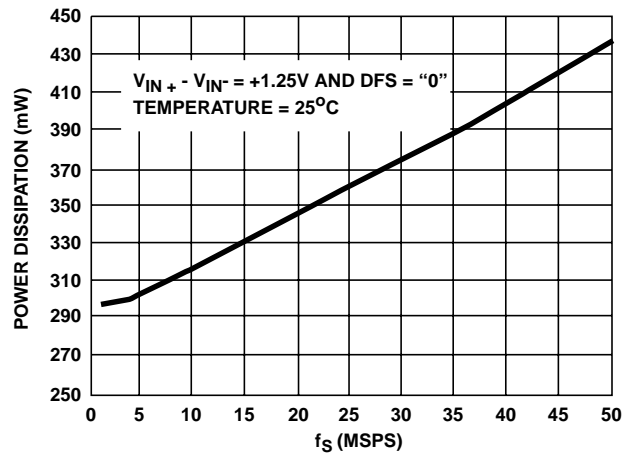


FIGURE 6. POWER DISSIPATION vs SAMPLE FREQUENCY



**Typical Performance Curves** (Continued)

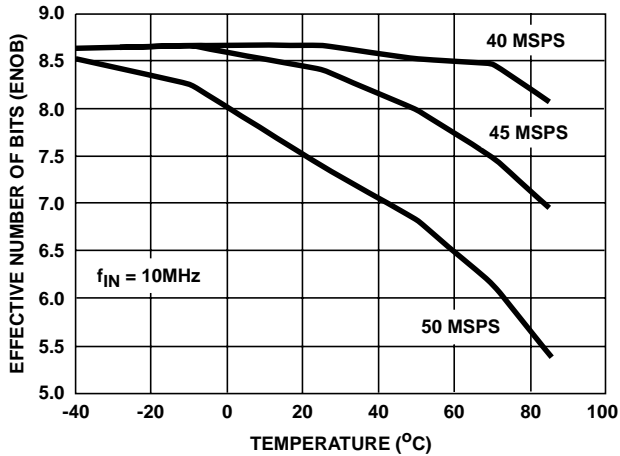


FIGURE 7. EFFECTIVE NUMBER OF BITS (ENOB) vs TEMPERATURE AND SAMPLE FREQUENCY

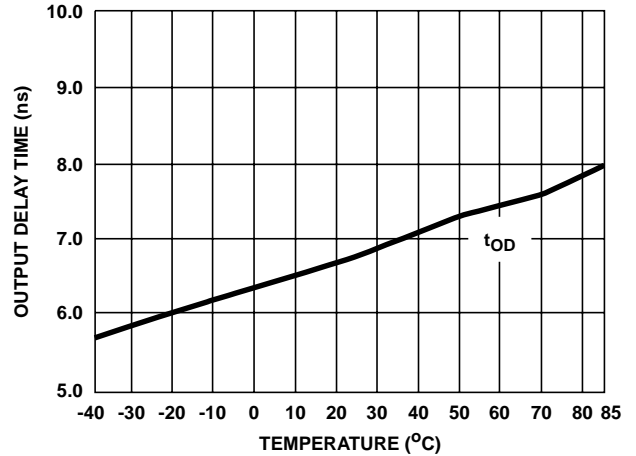


FIGURE 8. OUTPUT DELAY TIME ( $T_{OD}$ ) vs TEMPERATURE

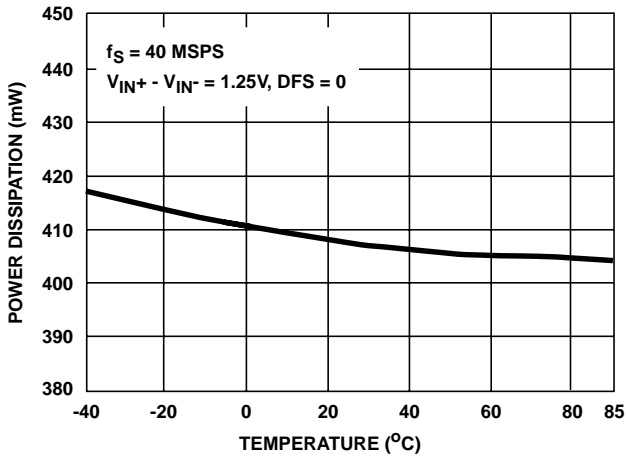


FIGURE 9. POWER DISSIPATION vs TEMPERATURE

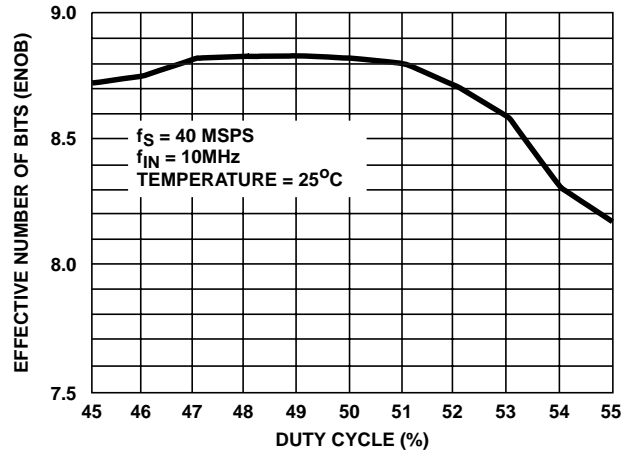
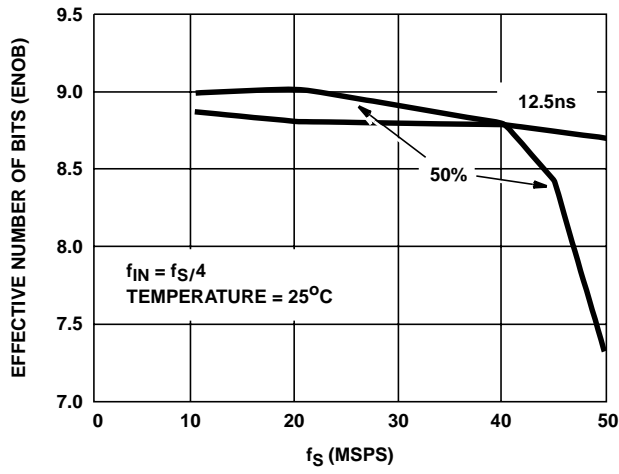
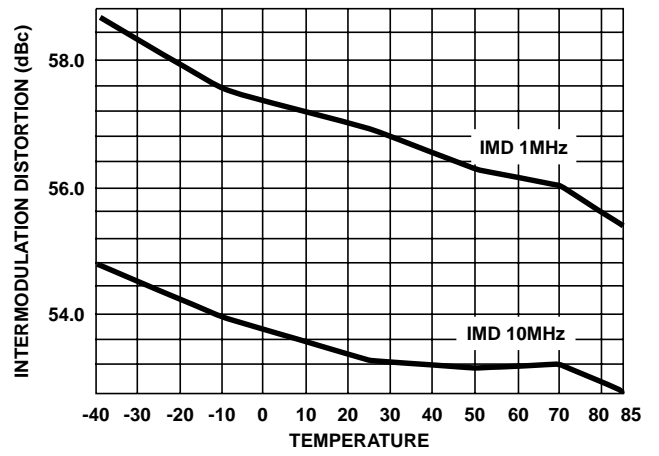


FIGURE 10. EFFECTIVE NUMBER OF BITS (ENOB) vs DUTY CYCLE ( $T_H/T_{TOTAL}$ )

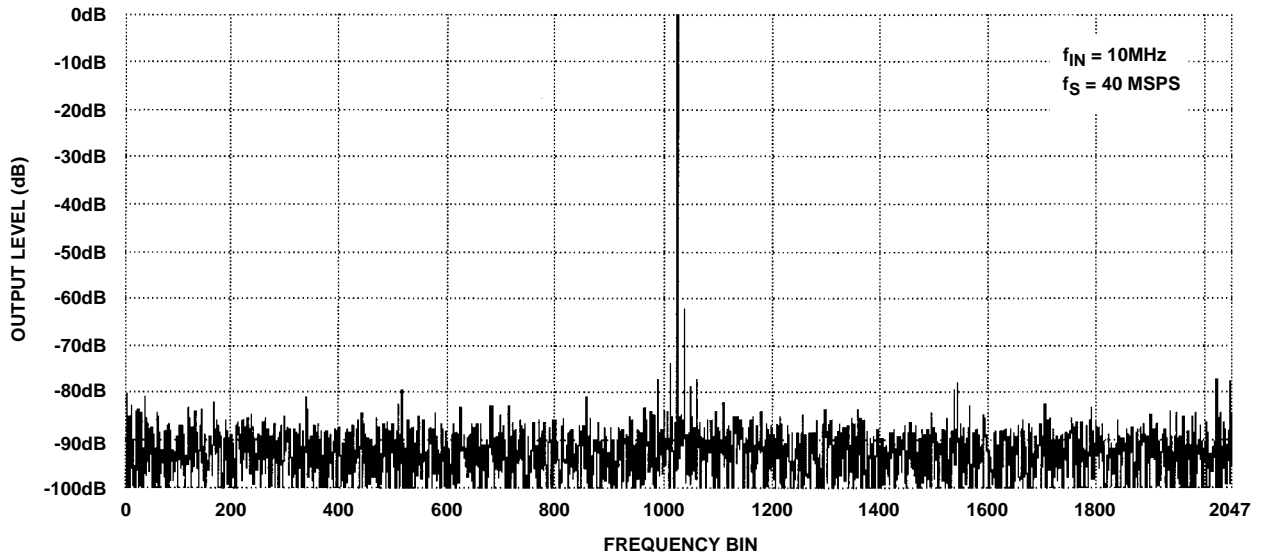
**Typical Performance Curves** (Continued)



**FIGURE 11. EFFECTIVE NUMBER OF BITS (ENOB) vs SAMPLE FREQUENCY**

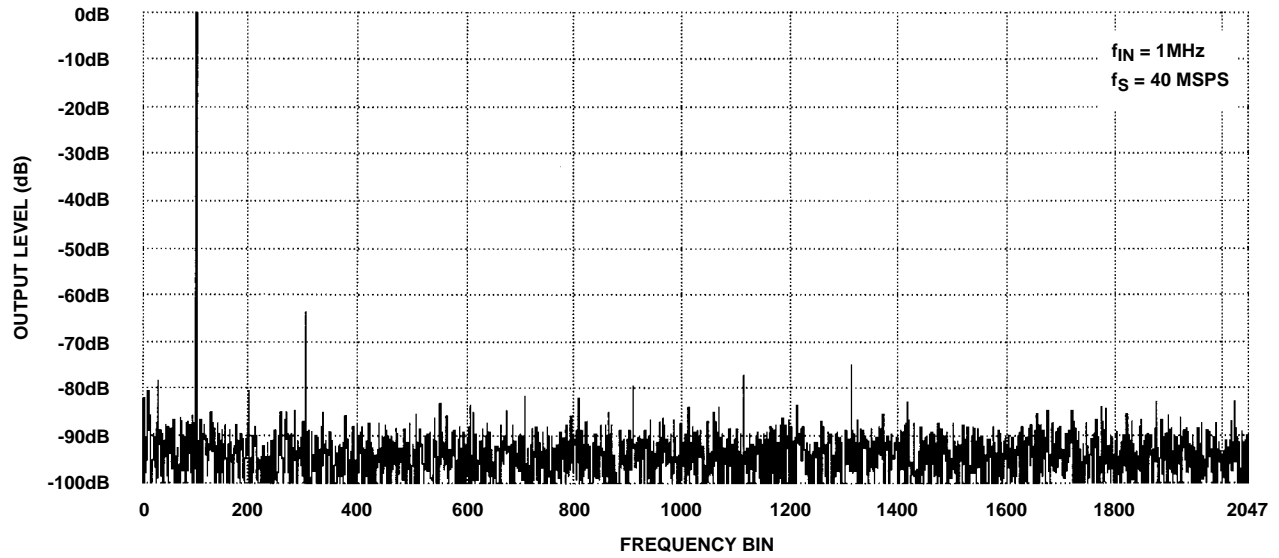


**FIGURE 12. INTERMODULATION DISTORTION (IMD) vs TEMPERATURE**



**FIGURE 13. 4096 POINT FFT SPECTRAL PLOT**

**Typical Performance Curves** (Continued)



**FIGURE 14. 4096 POINT FFT SPECTRAL PLOT**

**TABLE 1. PIN DESCRIPTION**

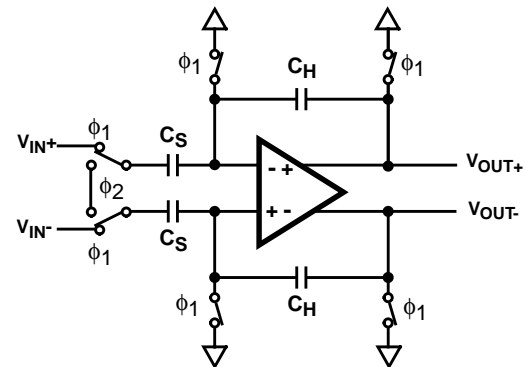
| PIN # | NAME              | DESCRIPTION                          |
|-------|-------------------|--------------------------------------|
| 1     | DV <sub>CC1</sub> | Digital Supply (+5.0V)               |
| 2     | DGND              | Digital Ground                       |
| 3     | DV <sub>CC1</sub> | Digital Supply (+5.0V)               |
| 4     | DGND              | Digital Ground                       |
| 5     | AV <sub>CC</sub>  | Analog Supply (+5.0V)                |
| 6     | AGND              | Analog Ground                        |
| 7     | V <sub>REF+</sub> | Positive Reference Voltage Input     |
| 8     | V <sub>REF-</sub> | Negative Reference Voltage Input     |
| 9     | V <sub>IN+</sub>  | Positive Analog Input                |
| 10    | V <sub>IN-</sub>  | Negative Analog Input                |
| 11    | V <sub>DC</sub>   | DC Bias Voltage Output               |
| 12    | AGND              | Analog Ground                        |
| 13    | AV <sub>CC</sub>  | Analog Supply (+5.0V)                |
| 14    | $\overline{OE}$   | Digital Output Enable Control Input  |
| 15    | DFS               | Data Format Select Input             |
| 16    | D9                | Data Bit 9 Output (MSB)              |
| 17    | D8                | Data Bit 8 Output                    |
| 18    | D7                | Data Bit 7 Output                    |
| 19    | D6                | Data Bit 6 Output                    |
| 20    | D5                | Data Bit 5 Output                    |
| 21    | DGND              | Digital Ground                       |
| 22    | CLK               | Sample Clock Input                   |
| 23    | DV <sub>CC2</sub> | Digital Output Supply (+3.3V to +5V) |
| 24    | D4                | Data Bit 4 Output                    |
| 25    | D3                | Data Bit 3 Output                    |
| 26    | D2                | Data Bit 2 Output                    |
| 27    | D1                | Data Bit 1 Output                    |
| 28    | D0                | Data Bit 0 Output (LSB)              |

## Detailed Description

### Theory of Operation

The HI5703 is a 10-bit fully differential sampling pipeline A/D converter with digital error correction. Figure 15 depicts the circuit for the front end differential-in-differential-out sample-and-hold (S/H). The switches are controlled by an internal clock which is a non-overlapping two phase signal,  $\phi_1$  and  $\phi_2$ , derived from the master clock. During the sampling phase,  $\phi_1$ , the input signal is applied to the sampling capacitors,  $C_S$ . At the same time the holding capacitors,  $C_H$ , are discharged to analog ground. At the falling edge of  $\phi_1$  the input signal is sampled on the bottom plates of the sampling capacitors. In the next clock phase,  $\phi_2$ , the two bottom plates of the sampling capacitors are connected

together and the holding capacitors are switched to the op-amp output nodes. The charge then redistributes between  $C_S$  and  $C_H$  completing one sample-and-hold cycle. The output is a fully-differential, sampled-data representation of the analog input. The circuit not only performs the sample-and-hold function but will also convert a single-ended input to a fully-differential output for the converter core. During the sampling phase, the  $V_{IN}$  pins see only the on-resistance of a switch and  $C_S$ . The relatively small values of these components result in a typical full power input bandwidth of 250MHz for the converter.



**FIGURE 15. ANALOG INPUT SAMPLE-AND-HOLD**

As illustrated in the functional block diagram and the timing diagram in Figure 1, nine identical pipeline subconverter stages, each containing a two-bit flash converter and a two-bit multiplying digital-to-analog converter, follow the S/H circuit with the tenth stage being a one bit flash converter. Each converter stage in the pipeline will be sampling in one phase and amplifying in the other clock phase. Each individual subconverter clock signal is offset by 180 degrees from the previous stage clock signal resulting in alternate stages in the pipeline performing the same operation.

The two-bit digital output of each stage is fed to a digital delay line controlled by the internal clock. The purpose of the delay line is to align the digital output data to the corresponding sampled analog input signal. This delayed data is fed to the digital error correction circuit which corrects the error in the output data with the information contained in the redundant bits to form the final ten bit output for the converter.

Because of the pipeline nature of this converter, the data on the bus is output at the 7th cycle of the clock after the analog sample is taken. This delay is specified as the data latency. After the data latency time, the data representing each succeeding sample is output at the following clock pulse. The output data is synchronized to the external clock by a double buffered latching technique.

The digital output bits are available in offset binary or two's complement format, the format being set by the Data Format Select (DFS) input.

### Reference Voltage Inputs, $V_{REF-}$ and $V_{REF+}$

The HI5703 requires two reference voltages connected to the  $V_{REF}$  pins. The HI5703 is tested with  $V_{REF-}$  equal to 2V and  $V_{REF+}$  equal to 3.25V for a fully differential input voltage range of  $\pm 1.25V$ .  $V_{REF+}$  and  $V_{REF-}$  can differ from the above voltages as long as the reference common mode voltage,  $((V_{REF+} + V_{REF-})/2)$ , does not exceed  $2.625V \pm 50mV$  and the limits on  $V_{REF+}$  and  $V_{REF-}$  are not exceeded.

In order to minimize overall converter noise it is recommended that adequate high frequency decoupling be provided at the reference voltage input pins,  $V_{REF+}$  and  $V_{REF-}$ .

### Analog Input, Differential Connection

The analog input to the HI5703 is a differential input that can be configured in various ways depending on the signal source and the required level of performance. A fully differential connection (Figure 16 and Figure 17) will give the best performance for the converter.

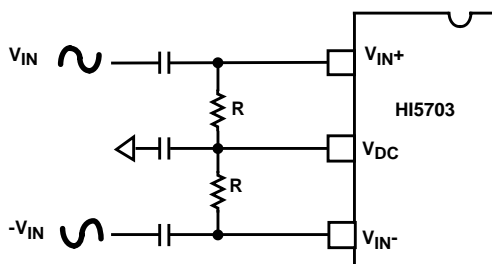


FIGURE 16. AC COUPLED DIFFERENTIAL INPUT

Since the HI5703 is powered by a single +5V analog supply, the analog input is limited to be between ground and +5V. For the differential input connection this implies the analog input common mode voltage can range from 0.625V to 4.375V. The performance of the ADC does not change significantly with the value of the analog input common mode voltage.

A DC voltage source,  $V_{DC}$ , equal to 2.8V (typical), is made available to the user to help simplify circuit design when using an AC coupled differential input. This low output impedance voltage source is not designed to be a reference but makes an excellent bias source and stays within the analog input common mode voltage range over temperature. It has a temperature coefficient of approximately  $+200ppm/^{\circ}C$ .

For the AC coupled differential input (Figure 16) assume the difference between  $V_{REF+}$ , typically 3.25V, and  $V_{REF-}$ , typically 2V, is 1.25V. Fullscale is achieved when the  $V_{IN+}$  and  $V_{IN-}$  inputs are  $1.25V_{P-P}$ , with  $V_{IN-}$  being 180 degrees out of phase with  $V_{IN+}$ . The converter will be at positive fullscale when the  $V_{IN+}$  input is at  $V_{DC} + 0.625V$  and  $V_{IN-}$  is at  $V_{DC} - 0.625V$  ( $V_{IN+} - V_{IN-} = 1.25V$ ). Conversely, the converter will be at negative full scale when the  $V_{IN+}$  input is equal to  $V_{DC} - 0.625V$  and  $V_{IN-}$  is at  $V_{DC} + 0.625V$  ( $V_{IN+} - V_{IN-} = -1.25V$ ).

The analog input can be DC coupled (Figure 17) as long as the inputs are within the analog input common mode voltage range ( $0.625V \leq V_{DC} \leq 4.375V$ ).

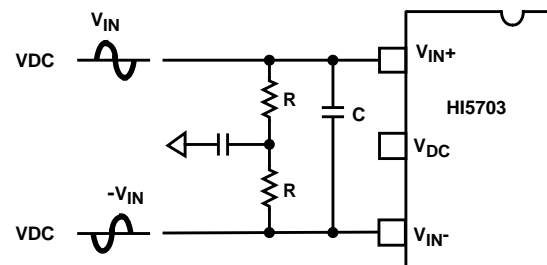


FIGURE 17. DC COUPLED DIFFERENTIAL INPUT

The resistors,  $R$ , in Figure 17 are not absolutely necessary but may be used as load setting resistors. A capacitor,  $C$ , connected from  $V_{IN+}$  to  $V_{IN-}$  will help filter any high frequency noise on the inputs, also improving performance. Values around 20pF are sufficient and can be used on AC coupled inputs as well. Note, however, that the value of capacitor  $C$  chosen must take into account the highest frequency component of the analog input signal.

### Analog Input, Single-Ended Connection

The configuration shown in Figure 18 may be used with a single ended AC coupled input.

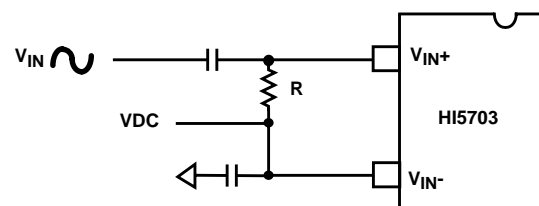
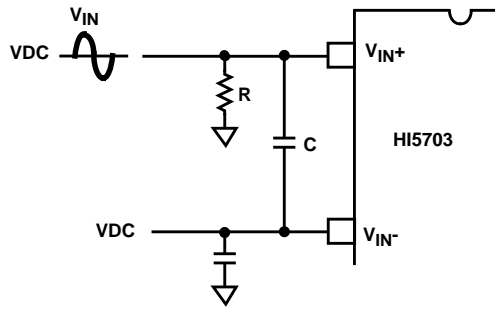


FIGURE 18. AC COUPLED SINGLE ENDED INPUT

Again, assume the difference between  $V_{REF+}$ , typically 3.25V, and  $V_{REF-}$ , typically 2V, is 1.25V. If  $V_{IN}$  is a  $2.5V_{P-P}$  sinewave, then  $V_{IN+}$  is a  $2.5V_{P-P}$  sinewave riding on a positive voltage equal to  $V_{DC}$ . The converter will be at positive fullscale when  $V_{IN+}$  is at  $V_{DC} + 1.25V$  and will be at negative fullscale when  $V_{IN+}$  is equal to  $V_{DC} - 1.25V$ . Sufficient headroom must be provided such that the input voltage never goes above +5V or below AGND. In this case,  $V_{DC}$  could range between 1.25V and 3.75V without a significant change in ADC performance. The simplest way to produce  $V_{DC}$  is to use the  $V_{DC}$  output of the HI5703.

The single ended analog input can be DC coupled (Figure 19) as long as the input is within the analog input common mode voltage range.



**FIGURE 19. DC COUPLED SINGLE ENDED INPUT**

The resistor, R, in Figure 19 is not absolutely necessary but may be used as a load setting resistor. A capacitor, C, connected from  $V_{IN+}$  to  $V_{IN-}$  will help filter any high frequency noise on the inputs, also improving performance. Values around 20pF are sufficient and can be used on AC coupled inputs as well. Note, however, that the value of capacitor C chosen must take into account the highest frequency component of the analog input signal.

A single ended source may give better overall system performance if it is first converted to differential before driving the HI5703. Refer to the application notes AN9534, "Using the HI5703 Evaluation Board", and AN9413, "Driving the Analog Input of the HI5702". Application note AN9413 applies to the HI5703 as well as the HI5702 and describes several different ways of driving the analog differential inputs.

#### **Digital Output Control and Clock Requirements**

The HI5703 provides a standard high-speed interface to external TTL logic families.

In order to ensure rated performance of the HI5703, the duty cycle of the clock should be held at 50%  $\pm$ 5%. It must also have low jitter and operate at standard TTL levels.

Performance of the HI5703 will only be guaranteed at conversion rates above 1 MSPS. This ensures proper performance of the internal dynamic circuits. Similarly, when power is first applied to the converter, a maximum of 20 cycles at a sample rate above 1 MSPS will have to be performed before valid data is available.

A Data Format Select (DFS) pin is provided which will determine the format of the digital data outputs. When at logic low, the data will be output in offset binary format. When at logic high, the data will be output in two's complement format. Refer to Table 2 for further information.

The output enable pin,  $\overline{OE}$ , when pulled high will three-state the digital outputs to a high impedance state. Set the  $\overline{OE}$  input to logic low for normal operation.

| $\overline{OE}$ INPUT | DIGITAL DATA OUTPUTS |
|-----------------------|----------------------|
| 0                     | Active               |
| 1                     | High Impedance       |

#### **Supply and Ground Considerations**

The HI5703 has separate analog and digital supply and ground pins to keep digital noise out of the analog signal path. The digital data outputs also have a separate supply pin,  $DV_{CC2}$ , which can be powered from a 3.3V to 5.0V supply. This allows the outputs to interface with 3.3V logic if so desired.

The part should be mounted on a board that provides separate low impedance connections for the analog and digital supplies and grounds. For best performance, the supplies to the HI5703 should be driven by clean, linear regulated supplies. The board should also have good high frequency decoupling capacitors mounted as close as possible to the converter. If the part is powered off a single supply then the analog supply and ground pins should be isolated by ferrite beads from the digital supply and ground pins.

Refer to the application notes "Using Intersil High Speed A/D Converters" (AN9214) for additional considerations when using high speed converters.

#### **Static Performance Definitions**

##### **Offset Error ( $V_{OS}$ )**

The midscale code transition should occur at a level  $1/4$  LSB above half-scale. Offset is defined as the deviation of the actual code transition from this point.

##### **Full-Scale Error (FSE)**

The last code transition should occur for an analog input that is  $3/4$  LSB below positive Fullscale (+FS) with the offset error removed. Full-scale error is defined as the deviation of the actual code transition from this point.

##### **Differential Linearity Error (DNL)**

DNL is the worst case deviation of a code width from the ideal value of 1 LSB.

##### **Integral Linearity Error (INL)**

INL is the worst case deviation of a code center from a best fit straight line calculated from the measured data.

##### **Power Supply Sensitivity**

Each of the power supplies are moved plus and minus 5% and the shift in the offset and full scale error (in LSBs) is noted.

TABLE 2. A/D CODE TABLE

| CODE CENTER DESCRIPTION     | DIFFERENTIAL INPUT VOLTAGE (V <sub>IN+</sub> - V <sub>IN-</sub> ) | OFFSET BINARY OUTPUT CODE (DFS LOW) |    |    |    |    |    |    |    |    |    | TWO'S COMPLEMENT OUTPUT CODE (DFS HIGH) |    |    |    |    |    |    |    |    |    |
|-----------------------------|---|-------------------------------------|----|----|----|----|----|----|----|----|----|---|----|----|----|----|----|----|----|----|----|
|                             |   | M S B                               |    |    |    |    |    |    |    |    |    | L S B                                   |    |    |    |    |    |    |    |    |    |
|                             |   | D9                                  | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | D9                                      | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
| +Full Scale (+FS) - 1/4 LSB | 1.24939V  | 1                                   | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 0                                       | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |    |
| +FS - 1 1/4 LSB             | 1.24695V  | 1                                   | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 0  | 0                                       | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 0  |    |
| +3/4 LSB                    | 1.83mV  | 1                                   | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0                                       | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |    |
| -1/4 LSB                    | -0.610mV  | 0                                   | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1                                       | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |    |
| -FS + 1 3/4 LSB             | -1.24573V   | 0                                   | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 1                                       | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  |    |
| -Full Scale (-FS) + 3/4 LSB | -1.24817V   | 0                                   | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1                                       | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |    |

NOTES:

- 8. The voltages listed above represent the ideal center of each output code shown as a function of the reference voltage.
- 9. V<sub>REF+</sub> = 3.25V and V<sub>REF-</sub> = 2.0V.

**Dynamic Performance Definitions**

Fast Fourier Transform (FFT) techniques are used to evaluate the dynamic performance of the HI5703. A low distortion sine wave is applied to the input, it is coherently sampled, and the output is stored in RAM. The data is then transformed into the frequency domain with an FFT and analyzed to evaluate the dynamic performance of the A/D. The sine wave input to the part is -0.5dB down from full scale for all these tests.

SNR and SINAD are quoted in dB. The distortion numbers are quoted in dBc (decibels with respect to carrier) and **DO NOT** include any correction factors for normalizing to full scale.

**Effective Number Of Bits (ENOB)**

The effective number of bits (ENOB) is calculated from the SINAD data by:

$$ENOB = (SINAD - 1.76 + V_{CORR}) / 6.02$$

where: V<sub>CORR</sub> = 0.5 dB

V<sub>CORR</sub> adjusts the ENOB for the amount the input is below fullscale.

**Signal To Noise and Distortion Ratio (SINAD)**

SINAD is the ratio of the measured RMS signal to RMS sum of all the other spectral components below the Nyquist frequency, f<sub>S</sub>/2, excluding DC.

**Signal To Noise Ratio (SNR)**

SNR is the ratio of the measured RMS signal to RMS noise at a specified input and sampling frequency. The noise is the RMS sum of all of the spectral components below f<sub>S</sub>/2 excluding the fundamental, the first five harmonics and DC.

**Total Harmonic Distortion (THD)**

THD is the ratio of the RMS sum of the first 5 harmonic components to the RMS value of the fundamental input signal.

**2nd and 3rd Harmonic Distortion**

This is the ratio of the RMS value of the applicable harmonic component to the RMS value of the fundamental input signal.

**Spurious Free Dynamic Range (SFDR)**

SFDR is the ratio of the fundamental RMS amplitude to the RMS amplitude of the next largest spectral component in the spectrum below f<sub>S</sub>/2.

**Intermodulation Distortion (IMD)**

Nonlinearities in the signal path will tend to generate intermodulation products when two tones, f<sub>1</sub> and f<sub>2</sub>, are present at the inputs. The ratio of the measured signal to the distortion terms is calculated. The terms included in the calculation are (f<sub>1</sub>+f<sub>2</sub>), (f<sub>1</sub>-f<sub>2</sub>), (2f<sub>1</sub>), (2f<sub>2</sub>), (2f<sub>1</sub>+f<sub>2</sub>), (2f<sub>1</sub>-f<sub>2</sub>), (f<sub>1</sub>+2f<sub>2</sub>), (f<sub>1</sub>-2f<sub>2</sub>). The ADC is tested with each tone 6dB below full scale.

**Transient Response**

Transient response is measured by providing a full scale transition to the analog input of the ADC and measuring the number of cycles it takes for the output code to settle within 10-bit accuracy.

**Over-Voltage Recovery**

Over-Voltage Recovery is measured by providing a full scale transition to the analog input of the ADC which overdrives the input by 200mV, and measuring the number of cycles it takes for the output code to settle within 10-bit accuracy.

### Full Power Input Bandwidth (FPBW)

Full power input bandwidth is the analog input frequency at which the amplitude of the digitally reconstructed output has decreased 3dB below the amplitude of the input sine wave. The input sine wave has an amplitude which swings from -FS to +FS. The bandwidth given is measured at the specified sampling frequency.

### Video Definitions

Differential Gain and Differential Phase are two commonly found video specifications for characterizing the distortion of a chrominance signal as it is offset through the input voltage range of an ADC.

### Differential Gain (DG)

Differential Gain is the peak difference in chrominance amplitude (in percent) relative to the reference burst.

### Differential Phase (DP)

Differential Phase is the peak difference in chrominance phase (in degrees) relative to the reference burst.

### Timing Definitions

Refer to Figure 1 and Figure 2 for these definitions.

### Aperture Delay ( $t_{AP}$ )

Aperture delay is the time delay between the external sample command (the falling edge of the clock) and the time

at which the signal is actually sampled. This delay is due to internal clock path propagation delays.

### Aperture Jitter ( $t_{AJ}$ )

Aperture jitter is the RMS variation in the aperture delay due to variation of internal clock path delays.

### Data Hold Time ( $t_H$ )

Data hold time is the time to where the previous data (N - 1) is no longer valid.

### Data Output Delay Time ( $t_{OD}$ )

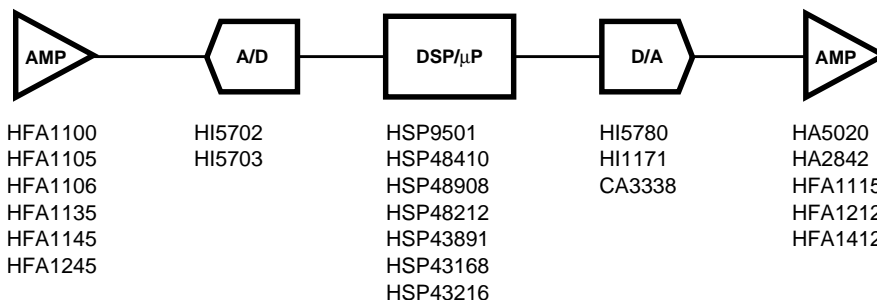
Data output delay time is the time to where the new data (N) is valid.

### Data Latency ( $t_{LAT}$ )

After the analog sample is taken, the digital data is output on the bus at the 7th cycle of the clock. This is due to the pipeline nature of the converter where the data has to ripple through the stages. This delay is specified as the data latency. After the data latency time, the data representing each succeeding sample is output at the following clock pulse. The digital data lags the analog input sample by 7 cycles.

### Power-Up initialization

This time is defined as the maximum number of clock cycles that are required to initialize the converter at power-up. The requirement arises from the need to initialize the dynamic circuits within the converter.

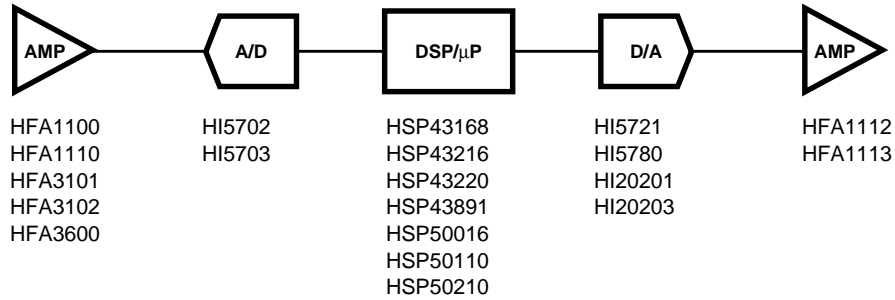


- |   |   |
|---|---|
| HFA1100: 850MHz Video Op Amp  | HSP48212: Digital Video Mixer                                       |
| HFA1105: 300MHz Video Op Amp  | HSP43891: Digital Filter, 30MHz, 9-Bit                              |
| HFA1106: 250MHz Video Op Amp with Bandwidth Limit Control           | HSP43168: Dual FIR Filter, 10-Bit, 33MHz/45MHz                      |
| HFA1135: 350MHz Video Op Amp with Output Limiting                   | HSP43216: Digital Half Band Filter                                  |
| HFA1145: 300MHz Video Op Amp with Output Disable                    | HI5780: 10-Bit, 80 MSPS, Video D/A Converter                        |
| HFA1245: Dual 350MHz Video Op Amp with Output Disable               | HI1171: 8-Bit, 40 MSPS, Video D/A Converter                         |
| HI5702: 10-Bit, 40 MSPS, A/D Converter                              | CA3338: 8-Bit, 50 MSPS, Video D/A Converter                         |
| HI5703: 10-Bit, 40 MSPS, Low Power A/D Converter                    | HA5020: 100MHz Video Op Amp   |
| HSP9501: Programmable Data Buffer                                   | HA2842: High Output Current, Video Op Amp                           |
| HSP48410: Histogrammer/Accumulating Buffer, 10-Bit Pixel Resolution | HFA1115: 225MHz Programmable Gain Video Buffer with Output Limiting |
| HSP48908: 2-D Convolver, 3 x 3 Kernal Convolution, 8-Bit            | HFA1212: 350MHz, Dual Programmable Gain Video Buffer                |
|   | HFA1412: 350MHz, Quad Programmable Gain Video Buffer                |

In addition, CMOS Logic Families in HC/HCT, AC/ACT, FCT and CD4000 are available.

FIGURE 20. 10-BIT VIDEO IMAGING COMPONENTS



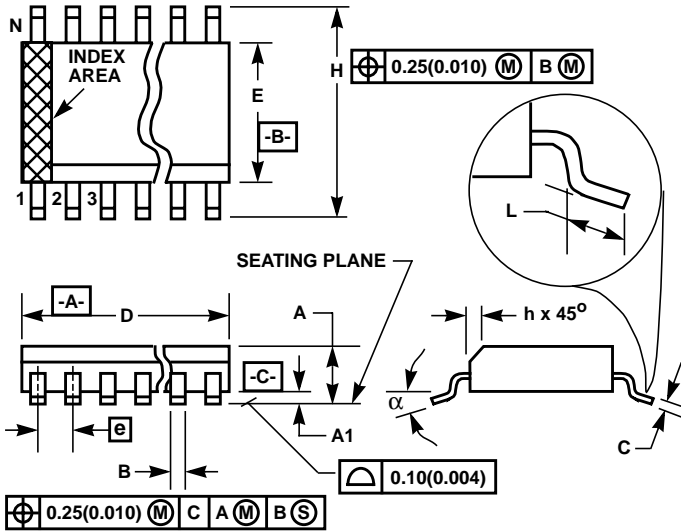


- HFA1100: 850MHz Op Amp
- HFA1110: 750MHz Unity Gain Video Buffer
- HFA3101: Gilbert Cell Transistor Array
- HFA3102: Dual Long-Tailed Pair Transistor Array
- HFA3600: Low Noise Amplifier/Mixer
- HI5702: 10-Bit, 40 MSPS, A/D Converter
- HI5703: 10-Bit, 40 MSPS, Low Power A/D Converter
- HSP43168: Dual FIR Filter, 10-Bit, 33MHz/45MHz
- HSP43216: Digital Half Band Filter
- HSP43220: Decimating Digital Filter
- HSP43891: Digital Filter, 30MHz, 9-Bit
- HSP50016: Digital Down Converter
- HSP50110: Digital Quadrature Tuner
- HSP50210: Digital Costas Loop
- HI5721: 10-Bit, 100 MSPS, Communications D/A Converter
- HI5780: 10-Bit, 80 MSPS, D/A Converter
- HI20201: 10-Bit, 160 MSPS, High Speed D/A Converter
- HI20203: 8-Bit, 160 MSPS, High Speed D/A Converter
- HFA1112: 850MHz Programmable Gain Video Buffer
- HFA1113: 850MHz Programmable Gain Video Buffer with Output Limiting

In addition, CMOS Logic Families in HC/HCT, AC/ACT, FCT and CD4000 are available.

**FIGURE 21. 10-BIT COMMUNICATIONS COMPONENTS**

**Small Outline Plastic Packages (SOIC)**



**M28.3 (JEDEC MS-013-AE ISSUE C)  
28 LEAD WIDE BODY SMALL OUTLINE PLASTIC PACKAGE**

| SYMBOL | INCHES   |        | MILLIMETERS |       | NOTES |
|--------|----------|--------|-------------|-------|-------|
|        | MIN      | MAX    | MIN         | MAX   |       |
| A      | 0.0926   | 0.1043 | 2.35        | 2.65  | -     |
| A1     | 0.0040   | 0.0118 | 0.10        | 0.30  | -     |
| B      | 0.013    | 0.0200 | 0.33        | 0.51  | 9     |
| C      | 0.0091   | 0.0125 | 0.23        | 0.32  | -     |
| D      | 0.6969   | 0.7125 | 17.70       | 18.10 | 3     |
| E      | 0.2914   | 0.2992 | 7.40        | 7.60  | 4     |
| e      | 0.05 BSC |        | 1.27 BSC    |       | -     |
| H      | 0.394    | 0.419  | 10.00       | 10.65 | -     |
| h      | 0.01     | 0.029  | 0.25        | 0.75  | 5     |
| L      | 0.016    | 0.050  | 0.40        | 1.27  | 6     |
| N      | 28       |        | 28          |       | 7     |
| alpha  | 0°       | 8°     | 0°          | 8°    | -     |

**NOTES:**

1. Symbols are defined in the "MO Series Symbol List" in Section 2.2 of Publication Number 95.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion and gate burrs shall not exceed 0.15mm (0.006 inch) per side.
4. Dimension "E" does not include interlead flash or protrusions. Interlead flash and protrusions shall not exceed 0.25mm (0.010 inch) per side.
5. The chamfer on the body is optional. If it is not present, a visual index feature must be located within the crosshatched area.
6. "L" is the length of terminal for soldering to a substrate.
7. "N" is the number of terminal positions.
8. Terminal numbers are shown for reference only.
9. The lead width "B", as measured 0.36mm (0.014 inch) or greater above the seating plane, shall not exceed a maximum value of 0.61mm (0.024 inch)
10. Controlling dimension: MILLIMETER. Converted inch dimensions are not necessarily exact.

Rev. 0 12/93

All Intersil semiconductor products are manufactured, assembled and tested under **ISO9000** quality systems certification.

*Intersil semiconductor products are sold by description only. Intersil Corporation reserves the right to make changes in circuit design and/or specifications at any time without notice. Accordingly, the reader is cautioned to verify that data sheets are current before placing orders. Information furnished by Intersil is believed to be accurate and reliable. However, no responsibility is assumed by Intersil or its subsidiaries for its use; nor for any infringements of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of Intersil or its subsidiaries.*

For information regarding Intersil Corporation and its products, see web site [www.intersil.com](http://www.intersil.com)

**Sales Office Headquarters**

**NORTH AMERICA**  
Intersil Corporation  
P. O. Box 883, Mail Stop 53-204  
Melbourne, FL 32902  
TEL: (321) 724-7000  
FAX: (321) 724-7240

**EUROPE**  
Intersil SA  
Mercure Center  
100, Rue de la Fusee  
1130 Brussels, Belgium  
TEL: (32) 2.724.2111  
FAX: (32) 2.724.22.05

**ASIA**  
Intersil Ltd.  
8F-2, 96, Sec. 1, Chien-kuo North,  
Taipei, Taiwan 104  
Republic of China  
TEL: 886-2-2515-8508  
FAX: 886-2-2515-8369