

## 8-BIT HIGH-SPEED ANALOG-TO-DIGITAL CONVERTER

### features

- **8-Bit Resolution**
- **Differential Linearity Error**
  - $\pm 0.3$  LSB Typ,  $\pm 1$  LSB Max (25°C)
  - $\pm 1$  LSB Max
- **Integral Linearity Error**
  - $\pm 0.6$  LSB,  $\pm 0.75$  LSB Max (25°C)
  - $\pm 1$  LSB Max
- **Maximum Conversion Rate of 40 Megasamples Per Second (MSPS) Max**
- **Internal Sample and Hold Function**
- **5-V Single Supply Operation**
- **Low Power Consumption . . . 85 mW Typ**
- **Analog Input Bandwidth . . .  $\geq 75$  MHz Typ**
- **Internal Reference Voltage Generators**

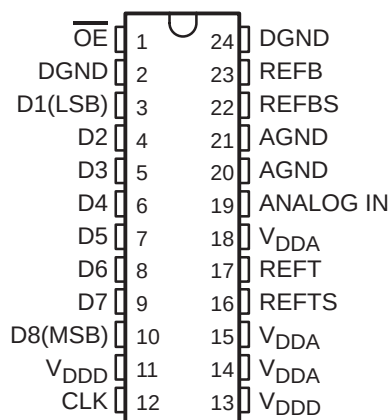
### applications

- **Quadrature Amplitude Modulation (QAM) and Quadrature Phase Shift Keying (QPSK) Demodulators**
- **Digital Television**
- **Charge-Coupled Device (CCD) Scanners**
- **Video Conferencing**
- **Digital Set-Top Box**
- **Digital Down Converters**
- **High-Speed Digital Signal Processor Front End**

### description

The TLC5540 is a high-speed, 8-bit analog-to-digital converter (ADC) that converts at sampling rates up to 40 megasamples per second (MSPS). Using a semiflash architecture and CMOS process, the TLC5540 is able to convert at high speeds while still maintaining low power consumption and cost. The analog input bandwidth of 75 MHz (typ) makes this device an excellent choice for undersampling applications. Internal resistors are provided to generate 2-V full-scale reference voltages from a 5-V supply, thereby reducing external components. The digital outputs can be placed in a high impedance mode. The TLC5540 requires only a single 5-V supply for operation.

PW OR NS PACKAGE  
(TOP VIEW)



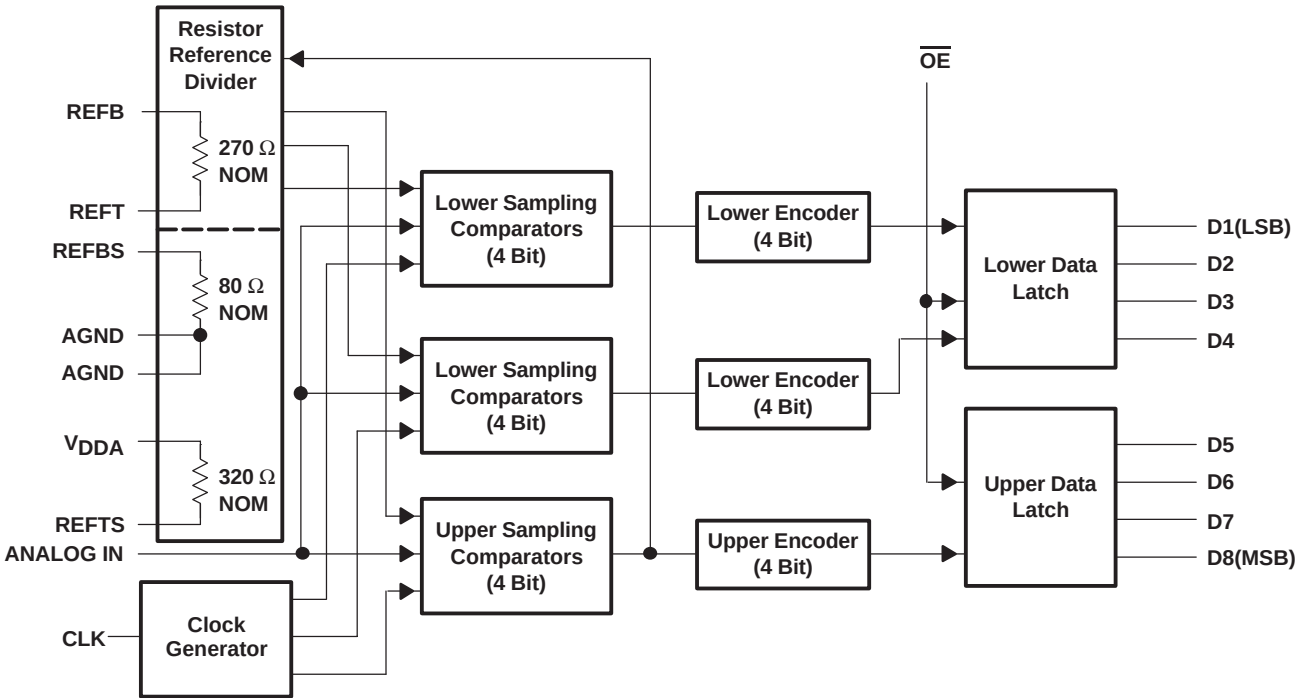
AVAILABLE OPTIONS

| T <sub>A</sub> | PACKAGE    |              |
|----------------|------------|--------------|
|                | TSSOP (PW) | SOP (NS)     |
| –0°C to 70°C   | TLC5540CPW | TLC5540CNSLE |
| –40°C to 85°C  | TLC5540IPW | TLC5540INSLE |

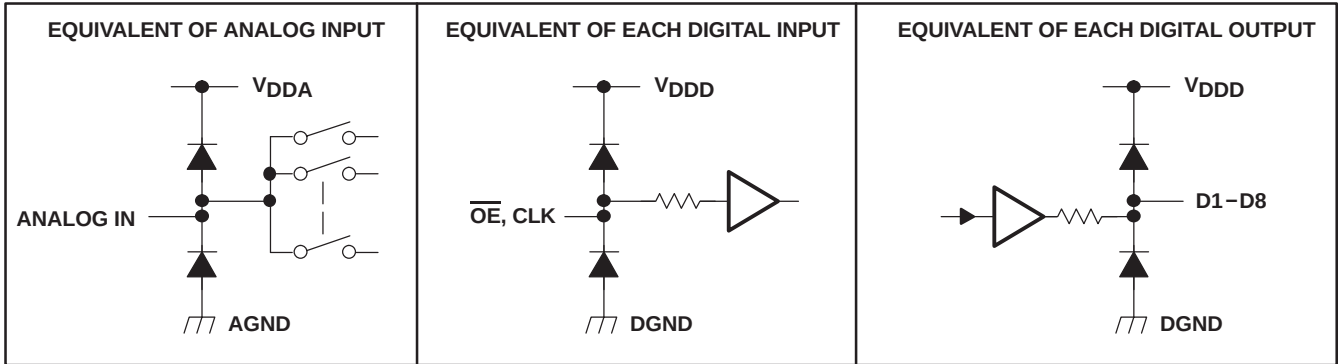


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# functional block diagram



# schematics of inputs and outputs



## Terminal Functions

| TERMINAL<br>NAME        | NO.        | I/O | DESCRIPTION                                                                                                                                                                                                                                       |
|-------------------------|------------|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| AGND                    | 20, 21     |     | Analog ground                                                                                                                                                                                                                                     |
| ANALOG IN               | 19         | I   | Analog input                                                                                                                                                                                                                                      |
| CLK                     | 12         | I   | Clock input                                                                                                                                                                                                                                       |
| DGND                    | 2, 24      |     | Digital ground                                                                                                                                                                                                                                    |
| D1–D8                   | 3–10       | O   | Digital data out. D1:LSB, D8:MSB                                                                                                                                                                                                                  |
| $\overline{\text{OE}}$  | 1          | I   | Output enable. When $\overline{\text{OE}} = \text{L}$ , data is enabled. When $\overline{\text{OE}} = \text{H}$ , D1–D8 is high impedance.                                                                                                        |
| $\text{V}_{\text{DDA}}$ | 14, 15, 18 |     | Analog $\text{V}_{\text{DD}}$                                                                                                                                                                                                                     |
| $\text{V}_{\text{DDD}}$ | 11, 13     |     | Digital $\text{V}_{\text{DD}}$                                                                                                                                                                                                                    |
| REFB                    | 23         | I   | ADC reference voltage in (bottom)                                                                                                                                                                                                                 |
| REFBS                   | 22         |     | Reference voltage (bottom). When using the internal voltage divider to generate a nominal 2-V reference, the REFBS terminal is shorted to the REFB terminal and the REFTS terminal is shorted to the REFT terminal (see Figure 13 and Figure 14). |
| REFT                    | 17         | I   | Reference voltage in (top)                                                                                                                                                                                                                        |
| REFTS                   | 16         |     | Reference voltage (top). When using the internal voltage divider to generate a nominal 2-V reference, the REFTS terminal is shorted to the REFT terminal and the REFBS terminal is shorted to the REFB terminal (see Figure 13 and Figure 14).    |

### absolute maximum ratings over operating free-air temperature range (unless otherwise noted)<sup>†</sup>

|                                                                                                                                                        |                                 |
|--------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| Supply voltage, $\text{V}_{\text{DDA}}$ , $\text{V}_{\text{DDD}}$                                                                                      | 7 V                             |
| Reference voltage input range, $\text{V}_{\text{I(REFT)}}$ , $\text{V}_{\text{I(REFB)}}$ , $\text{V}_{\text{I(REFBS)}}$ , $\text{V}_{\text{I(REFTS)}}$ | AGND to $\text{V}_{\text{DDA}}$ |
| Analog input voltage range, $\text{V}_{\text{I(ANLG)}}$                                                                                                | AGND to $\text{V}_{\text{DDA}}$ |
| Digital input voltage range, $\text{V}_{\text{I(DGTL)}}$                                                                                               | DGND to $\text{V}_{\text{DDD}}$ |
| Digital output voltage range, $\text{V}_{\text{O(DGTL)}}$                                                                                              | DGND to $\text{V}_{\text{DDD}}$ |
| Operating free-air temperature range, $\text{T}_{\text{A}}$ : TLC5540C                                                                                 | 0°C to 70°C                     |
| TLC5540I                                                                                                                                               | –40°C to 85°C                   |
| Storage temperature range, $\text{T}_{\text{stg}}$                                                                                                     | –55°C to 150°C                  |

<sup>†</sup> Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

**recommended operating conditions**

|                                                                 |                         | MIN                       | NOM                     | MAX                       | UNIT |
|-----------------------------------------------------------------|-------------------------|---------------------------|-------------------------|---------------------------|------|
| Supply voltage                                                  | V <sub>DDA</sub> – AGND | 4.75                      | 5                       | 5.25                      | V    |
|                                                                 | V <sub>DDD</sub> – AGND | 4.75                      | 5                       | 5.25                      |      |
|                                                                 | AGND – DGND             | –100                      | 0                       | 100                       | mV   |
| Reference input voltage (top), V <sub>I(REFT)</sub>             |                         | V <sub>I(REFB)</sub> +1.8 | V <sub>I(REFB)</sub> +2 | V <sub>DDA</sub>          | V    |
| Reference input voltage (bottom), V <sub>I(REFB)</sub>          |                         | 0                         | 0.6                     | V <sub>I(REFT)</sub> –1.8 | V    |
| Analog input voltage range, V <sub>I(ANLG)</sub> (see Note 1)   |                         | V <sub>I(REFB)</sub>      |                         | V <sub>I(REFT)</sub>      | V    |
| Full scale voltage, V <sub>I(REFT)</sub> – V <sub>I(REFB)</sub> |                         | 1.8                       |                         | 5                         | V    |
| High-level input voltage, V <sub>IH</sub>                       |                         | 4                         |                         |                           | V    |
| Low-level input voltage, V <sub>IL</sub>                        |                         |                           |                         | 1                         | V    |
| Pulse duration, clock high, t <sub>W(H)</sub>                   |                         | 12.5                      |                         |                           | ns   |
| Pulse duration, clock low, t <sub>W(L)</sub>                    |                         | 12.5                      |                         |                           | ns   |
| Operating free-air temperature, T <sub>A</sub>                  | TLC5540C                | 0                         |                         | 70                        | °C   |
|                                                                 | TLC5540I                | –40                       |                         | 85                        | °C   |

(1)  $1.8\text{ V} \leq V_{I(REFT)} - V_{I(REFB)} < V_{DD}$

**electrical characteristics at  $V_{DD} = 5\text{ V}$ ,  $V_{I(REFT)} = 2.6\text{ V}$ ,  $V_{I(REFB)} = 0.6\text{ V}$ ,  $f_s = 40\text{ MSPS}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)**

| PARAMETER                           |                                                        | TEST CONDITIONS†                                                                    |                                                                     | MIN  | TYP  | MAX   | UNIT |
|-------------------------------------|--------------------------------------------------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------|------|------|-------|------|
| E <sub>L</sub>                      | Linearity error, integral                              | f <sub>S</sub> = 40 MSPS,<br>V <sub>I</sub> = 0.6 V to 2.6 V                        | T <sub>A</sub> = 25°C                                               |      | ±0.6 | ±1    | LSB  |
|                                     |                                                        |                                                                                     | T <sub>A</sub> = MIN to MAX                                         |      |      | ±1    |      |
| E <sub>D</sub>                      | Linearity error, differential                          |                                                                                     | T <sub>A</sub> = 25°C                                               |      | ±0.3 | ±0.75 |      |
|                                     |                                                        |                                                                                     | T <sub>A</sub> = MIN to MAX                                         |      |      | ±1    |      |
|                                     | Self bias (1), V <sub>RB</sub>                         | Short REFB to REFBS                                                                 | See Figure 13                                                       | 0.57 | 0.61 | 0.65  | V    |
|                                     | Self bias (1), V <sub>RT</sub>                         | Short REFT to REFTS                                                                 |                                                                     | 2.47 | 2.63 | 2.80  |      |
|                                     | Self bias (2), V <sub>RB</sub>                         | Short REFB to AGND                                                                  | See Figure 14                                                       | AGND |      |       |      |
|                                     | Self bias (2), V <sub>RT</sub>                         | Short REFT to REFTS                                                                 |                                                                     | 2.18 | 2.29 | 2.4   |      |
| I <sub>ref</sub>                    | Reference-voltage current                              | V <sub>I</sub> (REFT) - V <sub>I</sub> (REFB) = 2 V                                 |                                                                     | 5.2  | 7.5  | 12    | mA   |
| R <sub>ref</sub>                    | Reference-voltage resistor                             | Between REFT and REFB terminals                                                     |                                                                     | 165  | 270  | 350   | Ω    |
| C <sub>i</sub>                      | Analog input capacitance                               | V <sub>I</sub> (ANLG) = 1.5 V + 0.07 V <sub>rms</sub>                               |                                                                     |      | 4    |       | pF   |
| E <sub>ZS</sub>                     | Zero-scale error                                       | V <sub>I</sub> (REFT) - V <sub>I</sub> (REFB) = 2 V                                 |                                                                     | -18  | -43  | -68   | mV   |
| E <sub>FS</sub>                     | Full-scale error                                       |                                                                                     |                                                                     | -25  | 0    | 25    |      |
| I <sub>IH</sub>                     | High-level input current                               | V <sub>DD</sub> = 5.25 V,                                                           | V <sub>IH</sub> = V <sub>DD</sub>                                   |      |      | 5     | μA   |
| I <sub>IL</sub>                     | Low-level input current                                | V <sub>DD</sub> = 5.25 V,                                                           | V <sub>IL</sub> = 0                                                 |      |      | 5     |      |
| I <sub>OH</sub>                     | High-level output current                              | OE = GND,                                                                           | V <sub>DD</sub> = 4.75 V, V <sub>OH</sub> = V <sub>DD</sub> - 0.5 V | -1.5 |      |       | mA   |
| I <sub>OL</sub>                     | Low-level output current                               | OE = GND,                                                                           | V <sub>DD</sub> = 4.75 V, V <sub>OL</sub> = 0.4 V                   | 2.5  |      |       |      |
| I <sub>OZH</sub> (I <sub>kg</sub> ) | High-level high-impedance-state output leakage current | OE = V <sub>DD</sub> ,                                                              | V <sub>DD</sub> = 5.25, V <sub>OH</sub> = V <sub>DD</sub>           |      |      | 16    | μA   |
| I <sub>OZL</sub> (I <sub>kg</sub> ) | Low-level high-impedance-state output leakage current  | OE = V <sub>DD</sub> ,                                                              | V <sub>DD</sub> = 4.75, V <sub>OL</sub> = 0                         |      |      | 16    |      |
| I <sub>DD</sub>                     | Supply current                                         | f <sub>S</sub> = 40 MSPS, C <sub>L</sub> ≤ 25 pF, NTSC‡ ramp wave input, See Note 1 |                                                                     |      | 17   | 27    | mA   |

<sup>†</sup> Conditions marked MIN or MAX are as stated in recommended operating conditions.

<sup>‡</sup> National Television System Committee

(1) Supply current specification does not include  $I_{ref}$ .

**operating characteristics at  $V_{DD} = 5\text{ V}$ ,  $V_{RT} = 2.6\text{ V}$ ,  $V_{RB} = 0.6\text{ V}$ ,  $f_s = 40\text{ MSPS}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)**

| PARAMETER                   |                                   | TEST CONDITIONS†                                         |                         | MIN  | TYP | MAX  | UNIT    |
|-----------------------------|-----------------------------------|----------------------------------------------------------|-------------------------|------|-----|------|---------|
| f <sub>S</sub>              | Maximum conversion rate           | T <sub>A</sub> = MIN to MAX                              |                         | 40   |     |      | MSPS    |
| f <sub>S</sub>              | Minimum conversion rate           | T <sub>A</sub> = MIN to MAX                              |                         | 5    |     |      | MSPS    |
| BW                          | Analog input full-power bandwidth | At – 3 dB, V <sub>I</sub> (ANLG) = 2 V <sub>pp</sub>     |                         | 75   |     |      | MHz     |
| t <sub>pd</sub>             | Delay time, digital output        | C <sub>L</sub> ≤ 10 pF (see Note 2)                      |                         | 9    |     | 15   | ns      |
| t <sub>PHZ</sub>            | Disable time, output high to Hi-Z | C <sub>L</sub> ≤ 15 pF, I <sub>OH</sub> = –4.5 mA        |                         |      |     | 20   | ns      |
| t <sub>PLZ</sub>            | Disable time, output low to Hi-Z  | C <sub>L</sub> ≤ 15 pF, I <sub>OL</sub> = 5 mA           |                         |      |     | 20   | ns      |
| t <sub>PZH</sub>            | Enable time, Hi-Z to output high  | C <sub>L</sub> ≤ 15 pF, I <sub>OH</sub> = –4.5 mA        |                         |      |     | 15   | ns      |
| t <sub>PZL</sub>            | Enable time, Hi-Z to output low   | C <sub>L</sub> ≤ 15 pF, I <sub>OL</sub> = 5 mA           |                         |      |     | 15   | ns      |
| Differential gain           |                                   | NTSC 40 IRE‡ modulation wave, f <sub>S</sub> = 14.3 MSPS |                         | 1%   |     |      | degrees |
| Differential phase          |                                   |                                                          |                         | 0.7  |     |      |         |
| t <sub>AJ</sub>             | Aperture jitter time              |                                                          |                         | 30   |     |      | ps      |
| t <sub>d</sub> (s)          | Sampling delay time               |                                                          |                         | 4    |     |      | ns      |
| SNR                         | Signal-to-noise ratio             | f <sub>S</sub> = 20 MSPS                                 | f <sub>I</sub> = 1 MHz  | 47   |     |      | dB      |
|                             |                                   |                                                          | f <sub>I</sub> = 3 MHz  | 44   | 47  |      |         |
|                             |                                   |                                                          | f <sub>I</sub> = 6 MHz  | 46   |     |      |         |
|                             |                                   |                                                          | f <sub>I</sub> = 10 MHz | 45   |     |      |         |
|                             |                                   | f <sub>S</sub> = 40 MSPS                                 | f <sub>I</sub> = 3 MHz  | 45.2 |     |      |         |
|                             |                                   |                                                          | f <sub>I</sub> = 6 MHz  | 42   | 44  |      |         |
|                             |                                   |                                                          | f <sub>I</sub> = 10 MHz | 42   |     |      |         |
| ENOB                        | Effective number of bits          | f <sub>S</sub> = 20 MSPS                                 | f <sub>I</sub> = 1 MHz  | 7.64 |     | Bits |         |
|                             |                                   |                                                          | f <sub>I</sub> = 3 MHz  | 7.61 |     |      |         |
|                             |                                   |                                                          | f <sub>I</sub> = 6 MHz  | 7.47 |     |      |         |
|                             |                                   |                                                          | f <sub>I</sub> = 10 MHz | 7.16 |     |      |         |
|                             |                                   | f <sub>S</sub> = 40 MSPS                                 | f <sub>I</sub> = 3 MHz  | 7    |     |      |         |
|                             |                                   |                                                          | f <sub>I</sub> = 6 MHz  | 6.8  |     |      |         |
| THD                         | Total harmonic distortion         | f <sub>S</sub> = 20 MSPS                                 | f <sub>I</sub> = 1 MHz  | 43   |     | dBc  |         |
|                             |                                   |                                                          | f <sub>I</sub> = 3 MHz  | 35   | 42  |      |         |
|                             |                                   |                                                          | f <sub>I</sub> = 6 MHz  | 41   |     |      |         |
|                             |                                   |                                                          | f <sub>I</sub> = 10 MHz | 38   |     |      |         |
|                             |                                   | f <sub>S</sub> = 40 MSPS                                 | f <sub>I</sub> = 3 MHz  | 40   |     |      |         |
|                             |                                   |                                                          | f <sub>I</sub> = 6 MHz  | 38   |     |      |         |
| Spurious-free dynamic range |                                   | f <sub>S</sub> = 20 MSPS                                 | f <sub>I</sub> = 3 MHz  | 41   | 46  | dBc  |         |
|                             |                                   | f <sub>S</sub> = 40 MSPS                                 |                         | 42   |     |      |         |

<sup>†</sup> Conditions marked MIN or MAX are as stated in recommended operating conditions.

<sup>‡</sup> Institute of Radio Engineers

(2)  $C_L$  includes probe and jig capacitance.

## PARAMETER MEASUREMENT INFORMATION

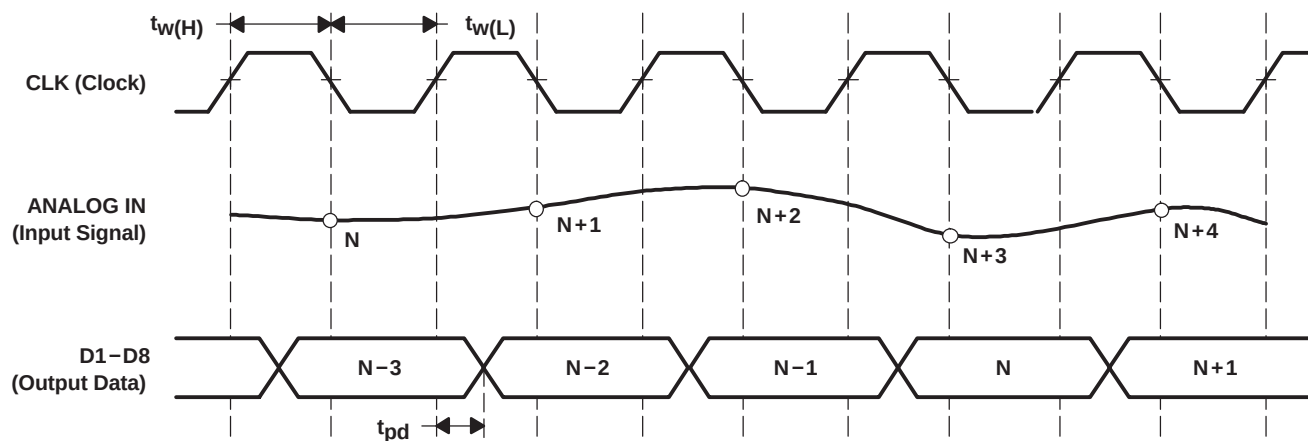


Figure 1. I/O Timing Diagram

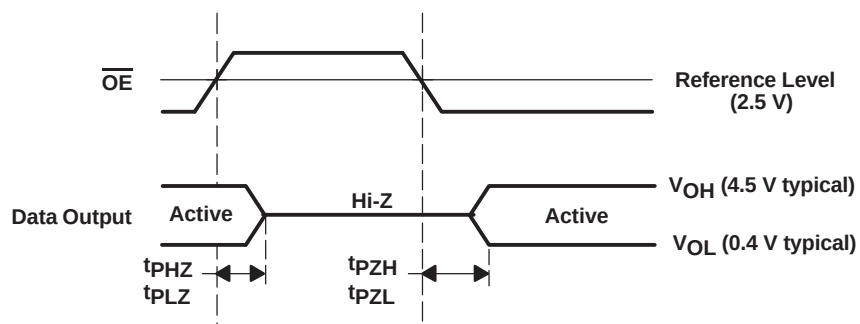


Figure 2. I/O Timing Diagram

# TYPICAL CHARACTERISTICS

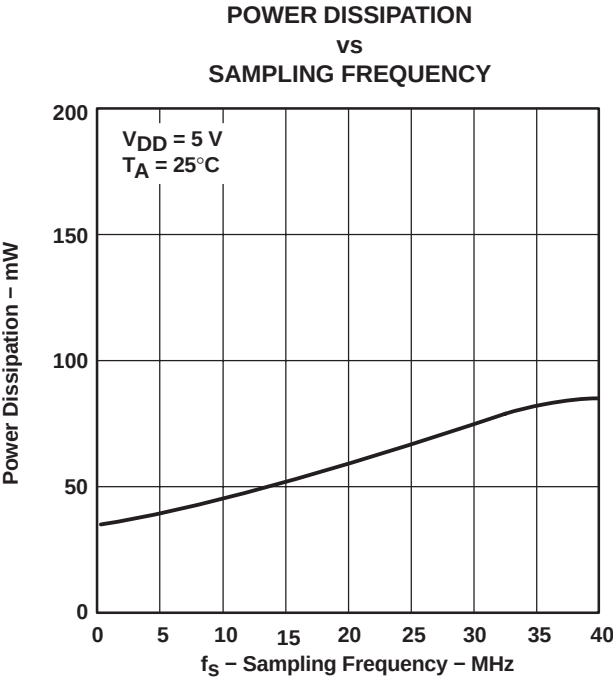


Figure 3

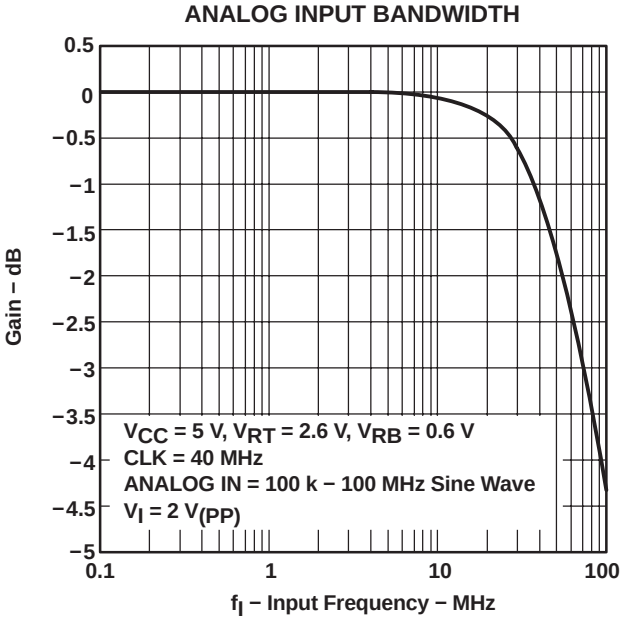


Figure 4

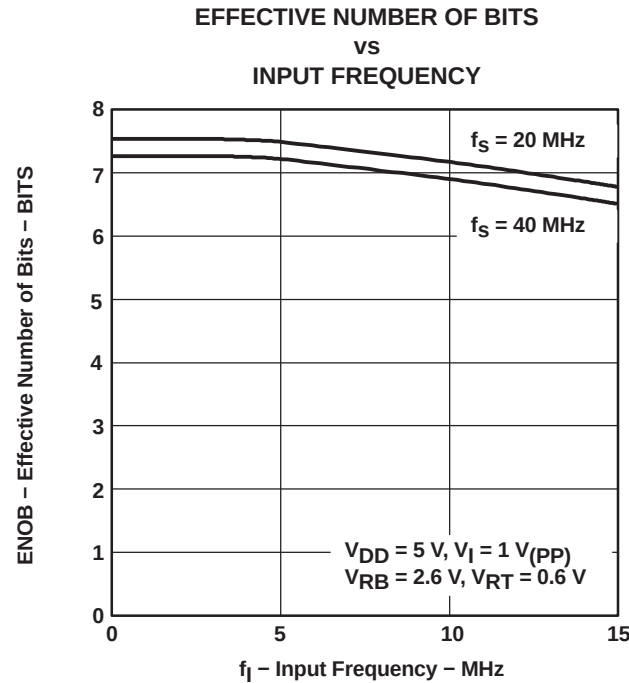


Figure 5

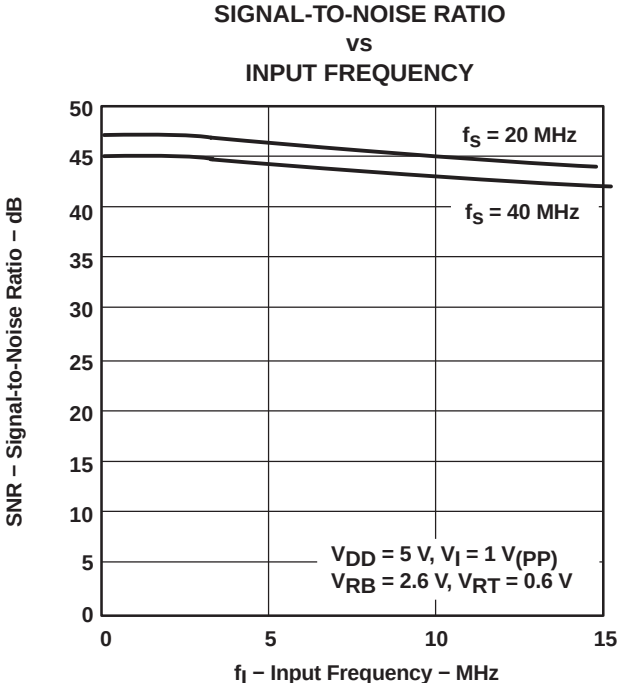


Figure 6



## TYPICAL CHARACTERISTICS

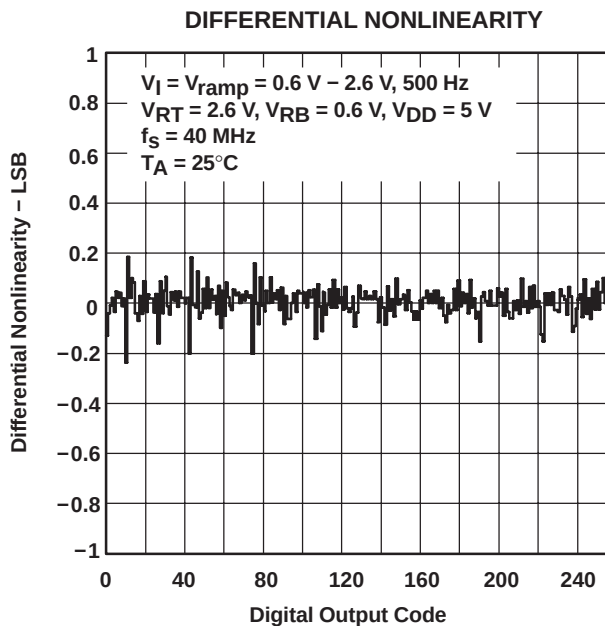


Figure 7

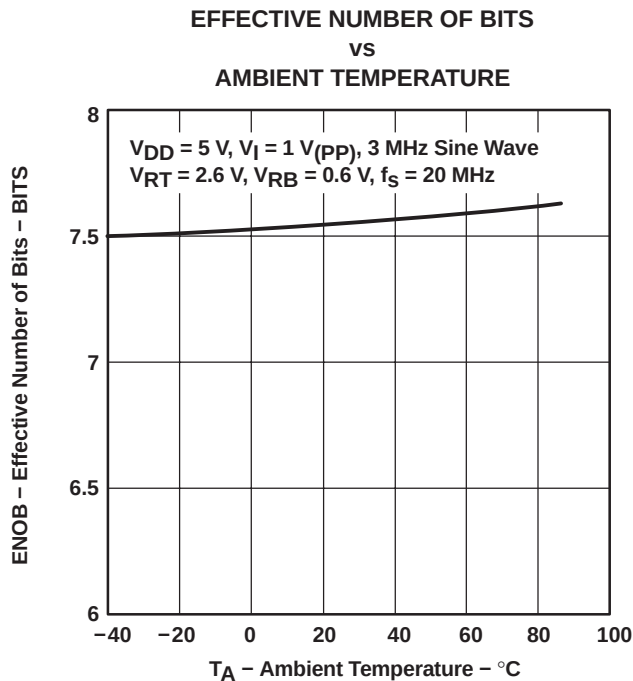


Figure 8

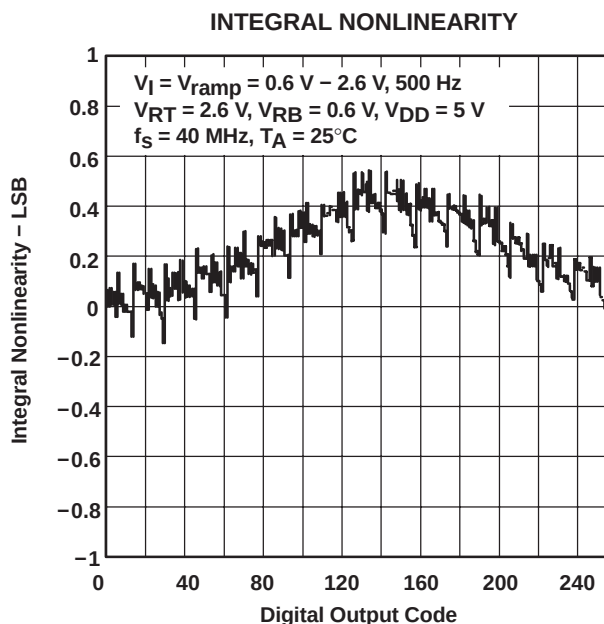


Figure 9

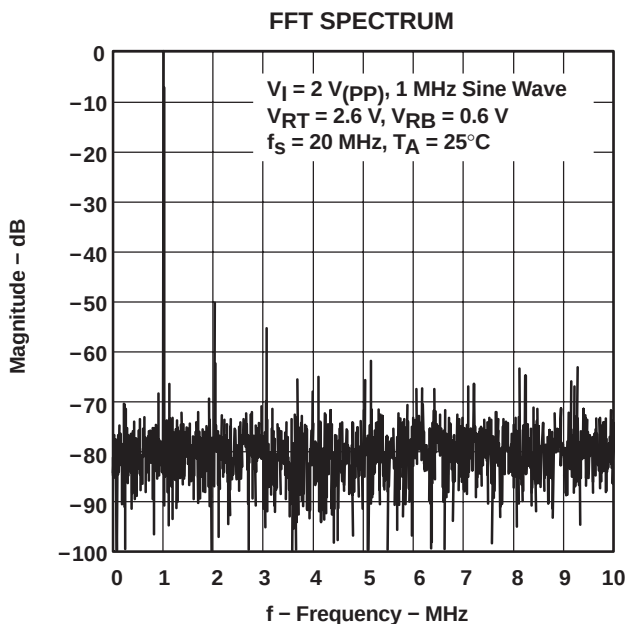


Figure 10

## APPLICATION INFORMATION

### grounding and power supply considerations

A signal ground is a low-impedance path for current to return to the source. Inside the TLC5540 A/D converter, the analog ground and digital ground are connected to each other through the substrate, which has a very small resistance ( $\sim 30\ \Omega$ ) to prevent internal latch-up. For this reason, it is strongly recommended that a printed circuit board (PCB) of at least 4 layers be used with the TLC5540 and the converter DGND and AGND pins be connected directly to the analog ground plane to avoid a ground loop. Figure 11 shows the recommended decoupling and grounding scheme for laying out a multilayer PC board with the TLC5540. This scheme ensures that the impedance connection between AGND and DGND is minimized so that their potential difference is negligible and noise source caused by digital switching current is eliminated.

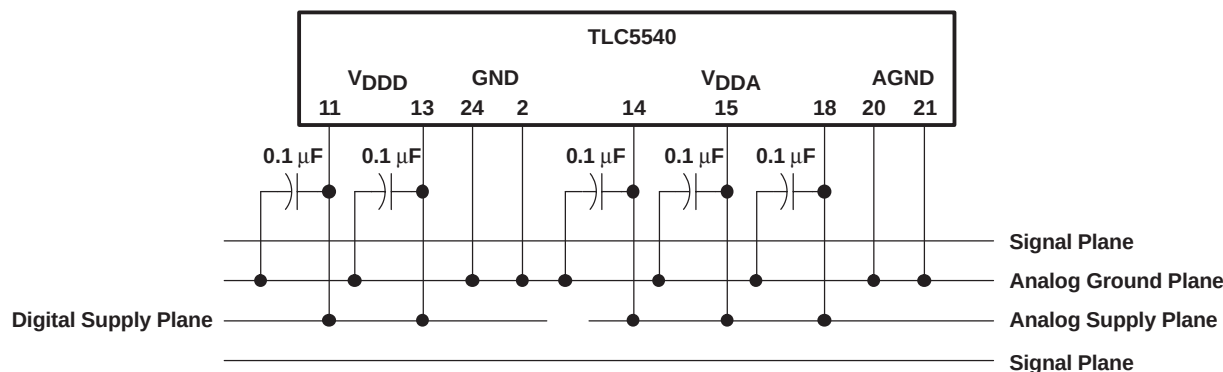


Figure 11.  $AV_{DD}$ ,  $DV_{DD}$ , AGND, and DGND Connections

### printed circuit board (PCB) layout considerations

When designing a circuit that includes high-speed digital and precision analog signals such as a high speed ADC, PCB layout is a key component to achieving the desired performance. The following recommendations should be considered during the prototyping and PCB design phase:

- Separate analog and digital circuitry physically to help eliminate capacitive coupling and crosstalk. When separate analog and digital ground planes are used, the digital ground and power planes should be several layers from the analog signals and power plane to avoid capacitive coupling.
- Full ground planes should be used. Do not use individual etches to return analog and digital currents or partial ground planes. For prototyping, breadboards should be constructed with copper clad boards to maximize ground plane.
- The conversion clock, CLK, should be terminated properly to reduce overshoot and ringing. Any jitter on the conversion clock degrades ADC performance. A high-speed CMOS buffer such as a 74ACT04 or 74AC04 positioned close to the CLK terminal can improve performance.
- Minimize all etch runs as much as possible by placing components very close together. It also proves beneficial to place the ADC in a corner of the PCB nearest to the I/O connector analog terminals.
- It is recommended to place the digital output data latch (if used) as close to the TLC5540 as possible to minimize capacitive loading. If D0 through D7 must drive large capacitive loads, internal ADC noise may be experienced.

## PRINCIPLES OF OPERATION

### functional description

The TLC5540 uses a modified semiflash architecture as shown in the functional block diagram. The four most significant bits (MSBs) of every output conversion result are produced by the upper comparator block CB1. The four least significant bits (LSBs) of each alternate output conversion result are produced by the lower comparator blocks CB-A and CB-B in turn (see Figure 12).

The reference voltage that is applied to the lower comparator resistor string is one sixteenth of the amplitude of the reference applied to the upper comparator resistor string. The sampling comparators of the lower comparator block require more time to sample the lower voltages of the reference and residual input voltage. By applying the residual input voltage to alternate lower comparator blocks, each comparator block has twice as much time to sample and convert as would be the case if only one lower comparator block were used.

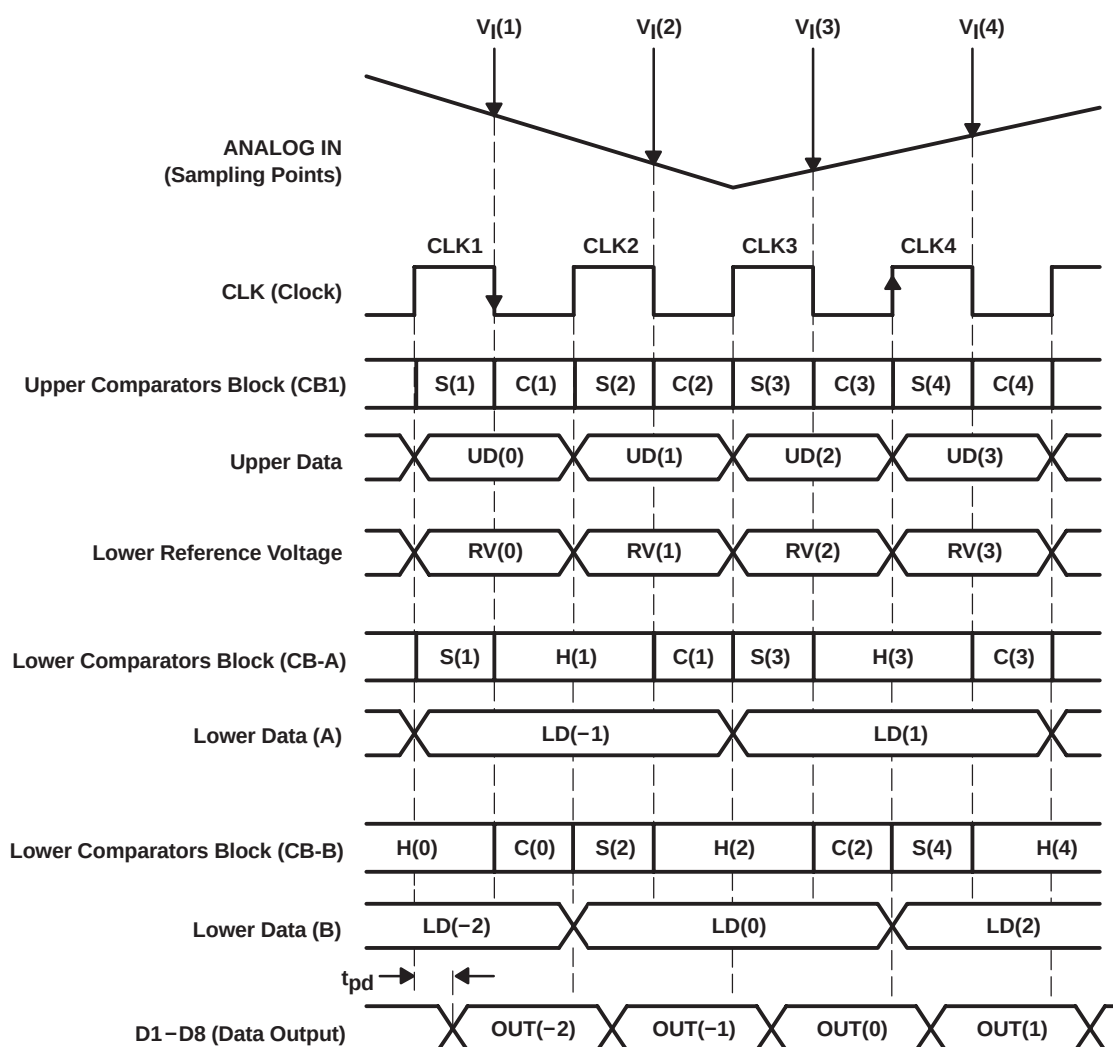


Figure 12. Internal Functional Timing Diagram

This conversion scheme, which reduces the required sampling comparators by 30 percent compared to standard semiflash architectures, achieves significantly higher sample rates than the conventional semiflash conversion method.

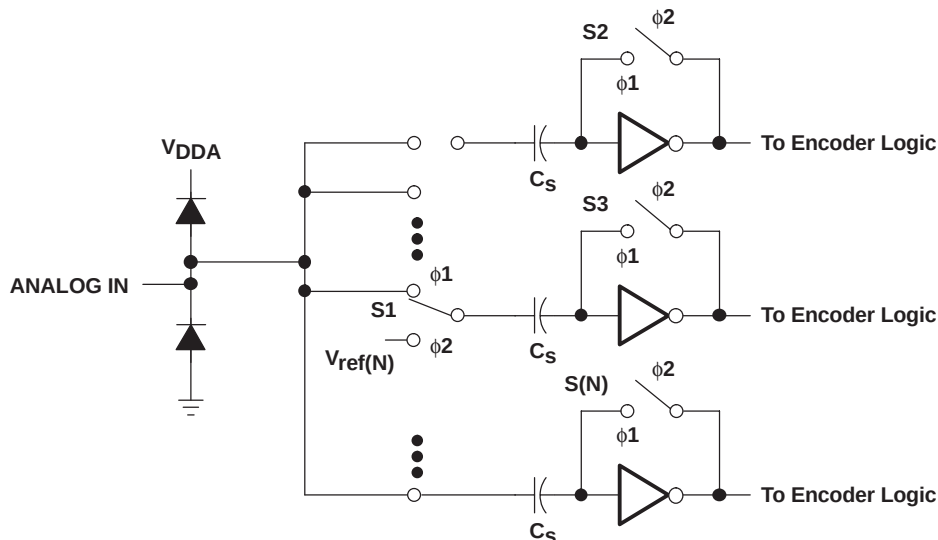
## PRINCIPLES OF OPERATION

**functional description (continued)**

The MSB comparator block converts on the falling edge of each applied clock cycle. The LSB comparator blocks CB-A and CB-B convert on the falling edges of the first and second following clock cycles, respectively. The timing diagram of the conversion algorithm is shown in Figure 12.

## analog input operation

The analog input stage to the TLC5540 is a chopper-stabilized comparator and is equivalently shown below:



### Figure 13. External Connections for Using the Internal Reference Resistor Divider

Figure 13 depicts the analog input for the TLC5540. The switches shown are controlled by two internal clocks,  $\phi 1$  and  $\phi 2$ . These are nonoverlapping clocks that are generated from the CLK input. During the sampling period,  $\phi 1$ , S1 is closed and the input signal is applied to one side of the sampling capacitor,  $C_S$ . Also during the sampling period, S2 through S(N) are closed. This sets the comparator input to approximately 2.5 V. The delta voltage is developed across  $C_S$ . During the comparison phase,  $\phi 2$ , S1 is switched to the appropriate reference voltage for the bit value N. S2 is opened and  $V_{ref(N)} - VC_S$  toggles the comparator output to the appropriate digital 1 or 0. The small resistance values for the switch, S1, and small value of the sampling capacitor combine to produce the wide analog input bandwidth of the TLC5540. The source impedance driving the analog input of the TLC5540 should be less than 100  $\Omega$  across the range of input frequency spectrum.

**reference inputs – REFB, REFT, REFBS, REFTS**

The range of analog inputs that can be converted are determined by REFB and REFT, REFT being the maximum reference voltage and REFB being the minimum reference voltage. The TLC5540 is tested with REFT = 2.6 V and REFB = 0.6 V producing a 2-V full-scale range. The TLC5540 can operate with REFT – REFB = 5 V, but the power dissipation in the reference resistor increases significantly (93 mW nominally). It is recommended that a 0.1  $\mu$ F capacitor be attached to REFB and REFT whether using externally or internally generated voltages.

## PRINCIPLES OF OPERATION

### internal reference voltage conversion

Three internal resistors allow the device to generate an internal reference voltage. These resistors are brought out on terminals  $V_{DDA}$ , REFTS, REFT, REFB, REFBS, and AGND. Two different bias voltages are possible without the use of external resistors.

Internal resistors are provided to develop  $REFT = 2.6\text{ V}$  and  $REFB = 0.6\text{ V}$  (bias option one) with only two external connections. This is developed with a 3-resistor network connected to  $V_{DDA}$ . When using this feature, connect REFT to REFTS and connect REFB to REFBS. For applications where the variance associated with  $V_{DDA}$  is acceptable, this internal voltage reference saves space and cost (see Figure 14).

A second internal bias option (bias two option) is shown in Figure 15. Using this scheme  $REFB = AGND$  and  $REFT = 2.28\text{ V}$  nominal. These bias voltage options can be used to provide the values listed in the following table.

Table 1. Bias Voltage Options

| BIAS OPTION | BIAS VOLTAGE |          |                   |
|-------------|--------------|----------|-------------------|
|             | $V_{RB}$     | $V_{RT}$ | $V_{RT} - V_{RB}$ |
| 1           | 0.61         | 2.63     | 2.02              |
| 2           | AGND         | 2.28     | 2.28              |

To use the internally-generated reference voltage, terminal connections should be made as shown in Figure 14 or Figure 15. The connections in Figure 14 provide the standard video 2-V reference.

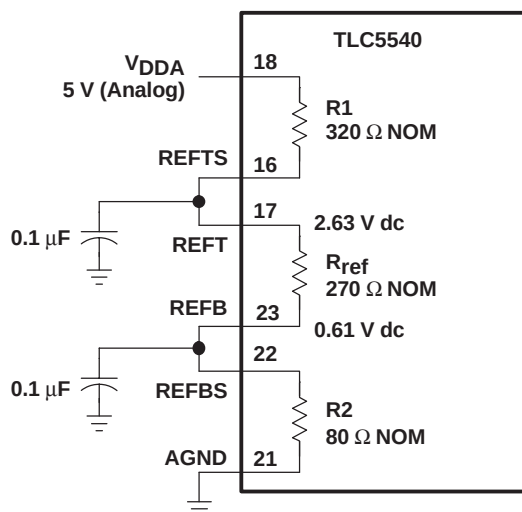


Figure 14. External Connections Using the Internal Bias One Option

PRINCIPLES OF OPERATION

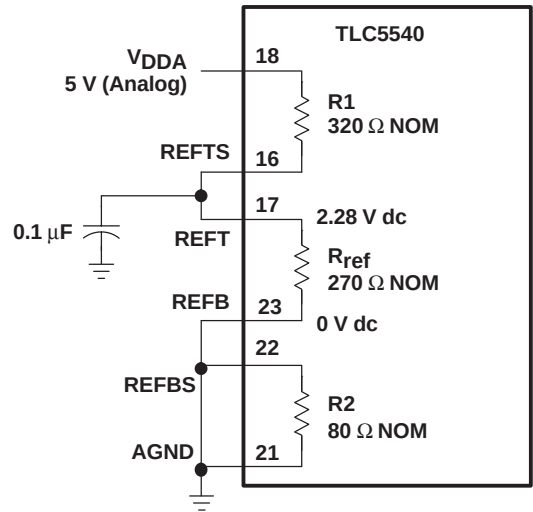


Figure 15. External Connections Using the Internal Bias Two Option

functional operation

Table 2 shows the TLC5540 functions.

Table 2. Functional Operation

| INPUT SIGNAL<br>VOLTAGE | STEP | DIGITAL OUTPUT CODE |   |   |   |   |   |   |     |
|-------------------------|------|---------------------|---|---|---|---|---|---|-----|
|                         |      | MSB                 |   |   |   |   |   |   | LSB |
| $V_{ref(T)}$            | 255  | 1                   | 1 | 1 | 1 | 1 | 1 | 1 | 1   |
| •                       | •    | •                   | • | • | • | • | • | • | •   |
| •                       | •    | •                   | • | • | • | • | • | • | •   |
| •                       | 128  | 1                   | 0 | 0 | 0 | 0 | 0 | 0 | 0   |
| •                       | 127  | 0                   | 1 | 1 | 1 | 1 | 1 | 1 | 1   |
| •                       | •    | •                   | • | • | • | • | • | • | •   |
| •                       | •    | •                   | • | • | • | • | • | • | •   |
| $V_{ref(B)}$            | 0    | 0                   | 0 | 0 | 0 | 0 | 0 | 0 | 0   |

## PACKAGING INFORMATION

| Orderable part number       | Status<br>(1) | Material type<br>(2) | Package   Pins  | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|-----------------------------|---------------|----------------------|-----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| TLC5540CNS.A                | Active        | Production           | SOP (NS)   24   | 34   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | TLC5540             |
| <a href="#">TLC5540CPW</a>  | Active        | Production           | TSSOP (PW)   24 | 60   TUBE             | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | 0 to 70      | P5540               |
| TLC5540CPW.A                | Active        | Production           | TSSOP (PW)   24 | 60   TUBE             | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 85    | P5540               |
| TLC5540INS.A                | Active        | Production           | SOP (NS)   24   | 34   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | TLC5540I            |
| <a href="#">TLC5540INSR</a> | Active        | Production           | SOP (NS)   24   | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | TLC5540I            |
| TLC5540INSR.A               | Active        | Production           | SOP (NS)   24   | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | TLC5540I            |
| <a href="#">TLC5540IPW</a>  | Active        | Production           | TSSOP (PW)   24 | 60   TUBE             | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 85    | Y5540               |
| TLC5540IPW.A                | Active        | Production           | TSSOP (PW)   24 | 60   TUBE             | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 85    | Y5540               |
| <a href="#">TLC5540IPWR</a> | Active        | Production           | TSSOP (PW)   24 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 85    | Y5540               |
| TLC5540IPWR.A               | Active        | Production           | TSSOP (PW)   24 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 85    | Y5540               |

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

<sup>(5)</sup> **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

<sup>(6)</sup> **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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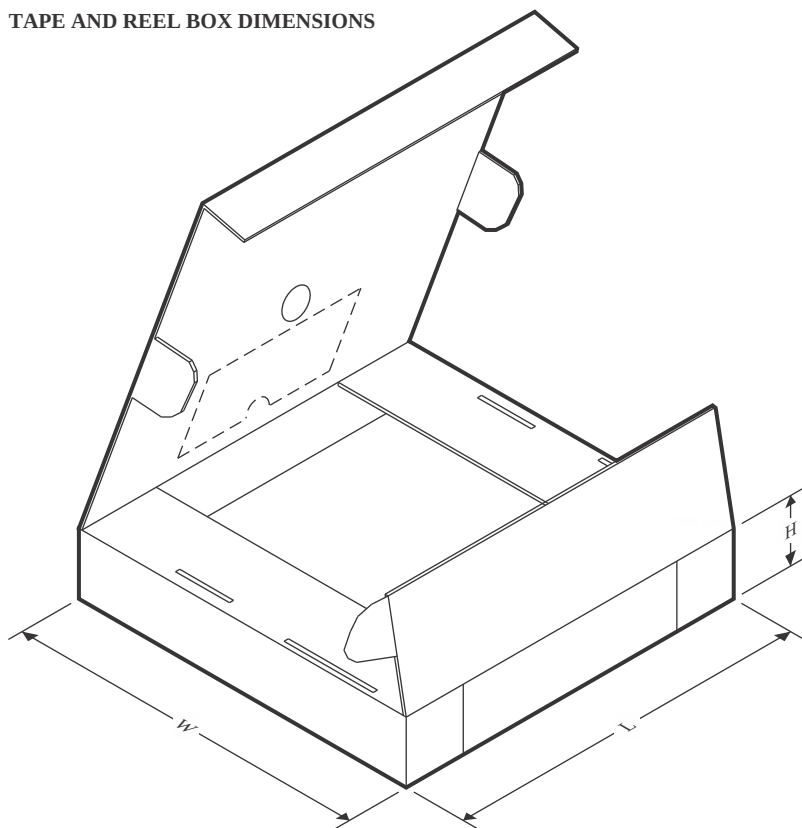
## TAPE AND REEL INFORMATION



\*All dimensions are nominal

| Device      | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|-------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TLC5540INSR | SOP          | NS              | 24   | 2000 | 330.0              | 24.4               | 8.5     | 15.3    | 2.6     | 12.0    | 24.0   | Q1            |
| TLC5540IPWR | TSSOP        | PW              | 24   | 2000 | 330.0              | 16.4               | 6.95    | 8.3     | 1.6     | 8.0     | 16.0   | Q1            |

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

| Device      | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|-------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TLC5540INSR | SOP          | NS              | 24   | 2000 | 350.0       | 350.0      | 43.0        |
| TLC5540IPWR | TSSOP        | PW              | 24   | 2000 | 350.0       | 350.0      | 43.0        |

**TUBE**


\*All dimensions are nominal

| Device       | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (μm) | B (mm) |
|--------------|--------------|--------------|------|-----|--------|--------|--------|--------|
| TLC5540CNS.A | NS           | SOP          | 24   | 34  | 530    | 10.5   | 4000   | 4.1    |
| TLC5540CPW   | PW           | TSSOP        | 24   | 60  | 530    | 10.2   | 3600   | 3.5    |
| TLC5540CPW.A | PW           | TSSOP        | 24   | 60  | 530    | 10.2   | 3600   | 3.5    |
| TLC5540INS.A | NS           | SOP          | 24   | 34  | 530    | 10.5   | 4000   | 4.1    |
| TLC5540IPW   | PW           | TSSOP        | 24   | 60  | 530    | 10.2   | 3600   | 3.5    |
| TLC5540IPW.A | PW           | TSSOP        | 24   | 60  | 530    | 10.2   | 3600   | 3.5    |

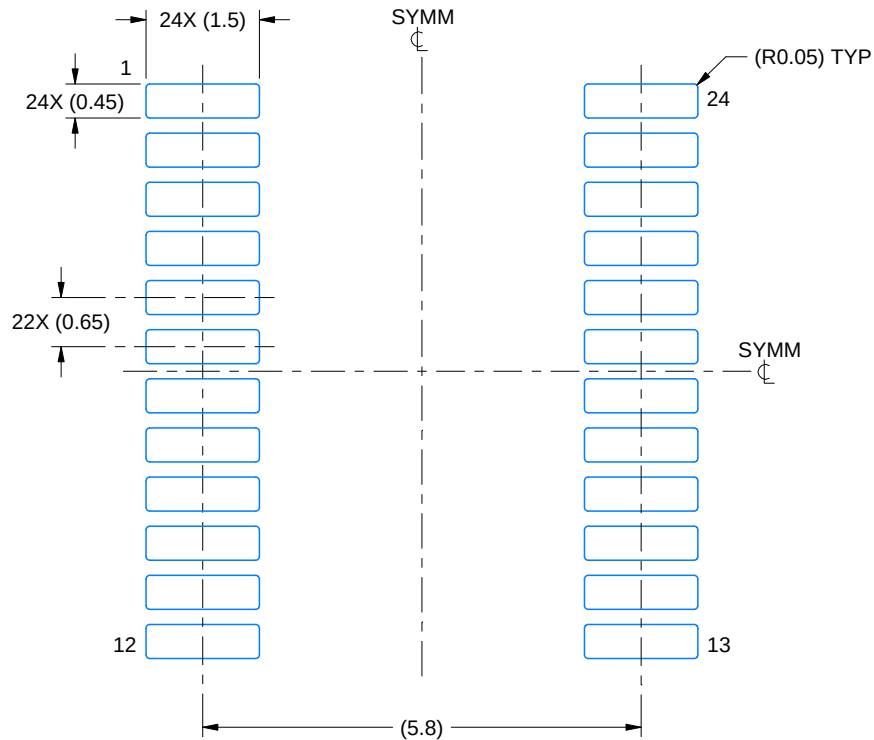


# EXAMPLE BOARD LAYOUT

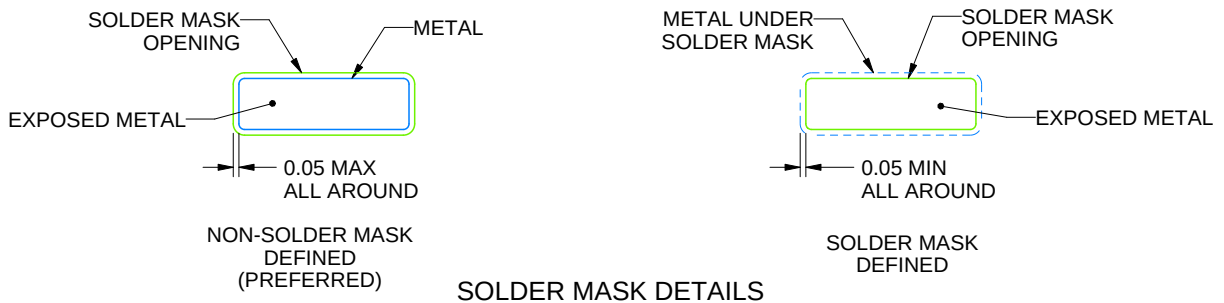
PW0024A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 10X



4220208/A 02/2017

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

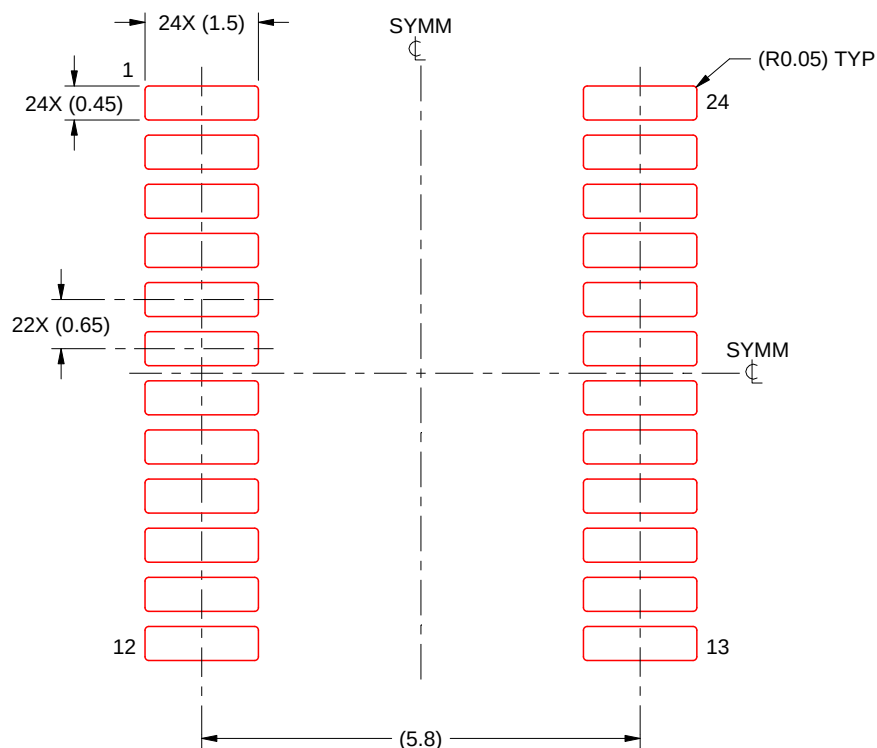
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

PW0024A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE: 10X

4220208/A 02/2017

NOTES: (continued)

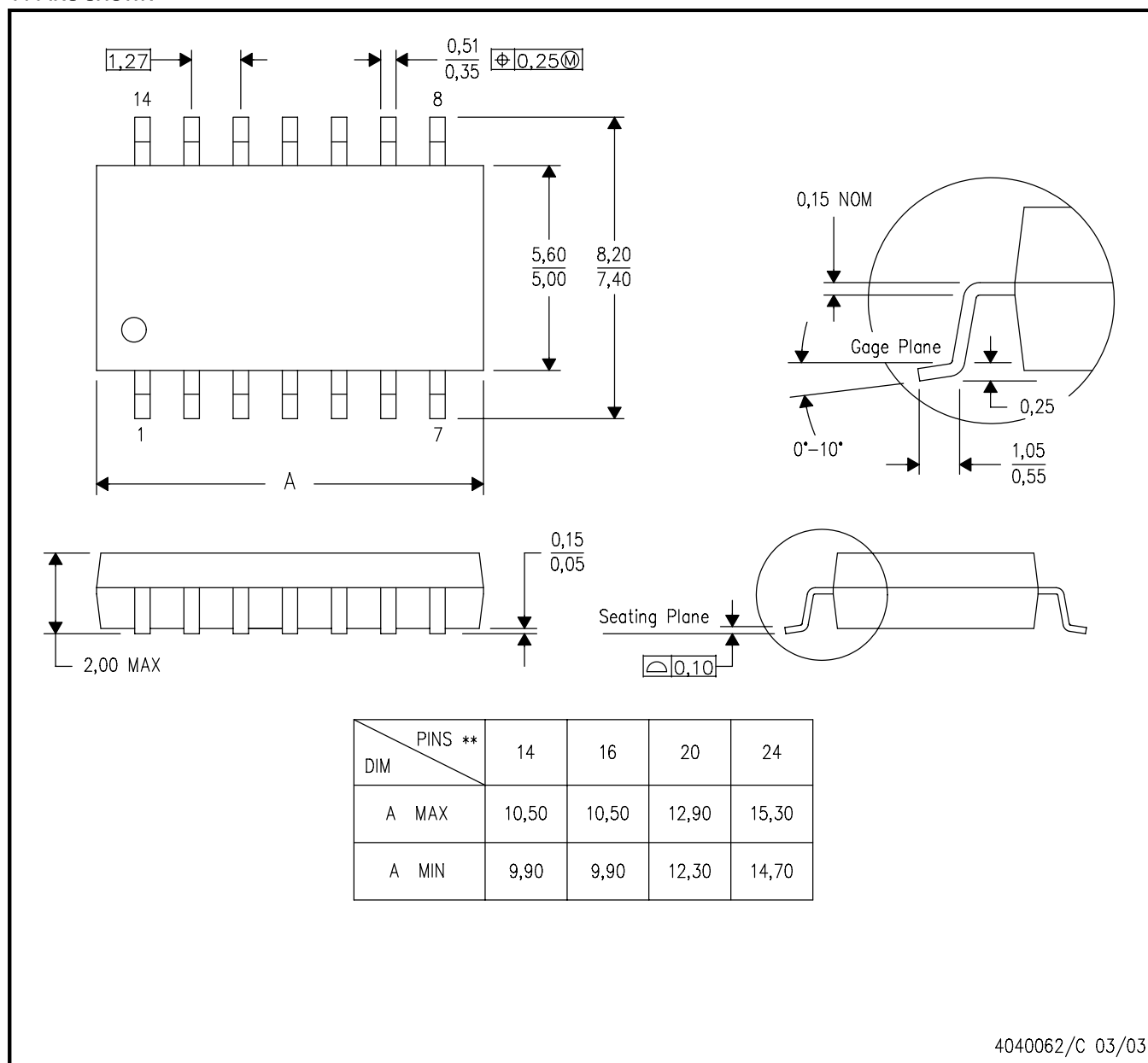
8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

# MECHANICAL DATA

NS (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

14-PINS SHOWN



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15.



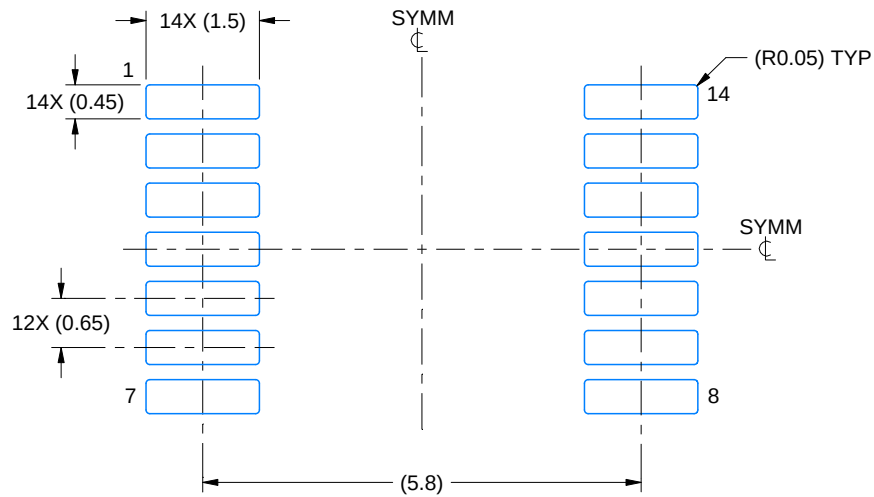


# EXAMPLE BOARD LAYOUT

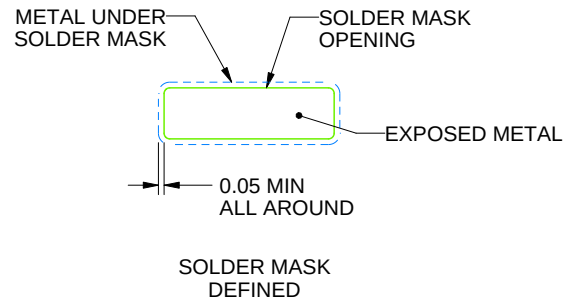
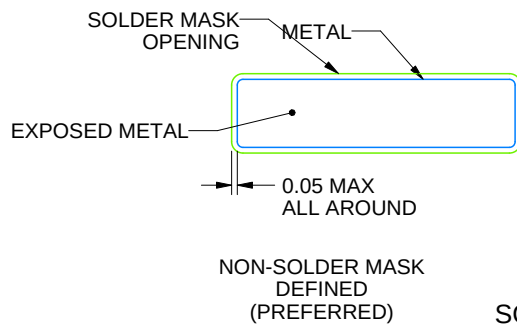
PW0014A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 10X



SOLDER MASK DETAILS

4220202/B 12/2023

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

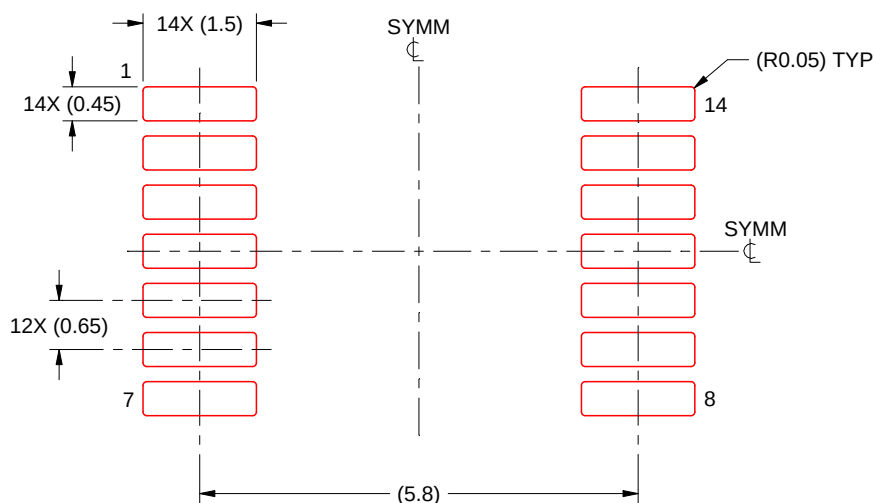
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

PW0014A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE: 10X

4220202/B 12/2023

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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