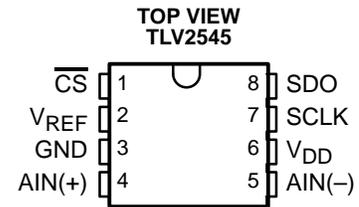
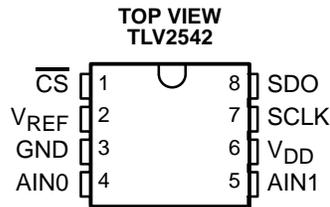
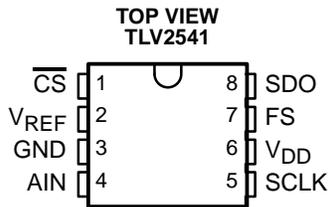


# TLV2541, TLV2542, TLV2545 2.7-V TO 5.5-V, LOW-POWER, 12-BIT, 140/200 KSPS, SERIAL ANALOG-TO-DIGITAL CONVERTERS WITH AUTOPOWER DOWN

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- Maximum Throughput . . . 140/200 KSPS
- Built-In Conversion Clock
- INL/DNL:  $\pm 1$  LSB Max, SINAD: 72 dB, SFDR: 85 dB,  $f_i = 20$  kHz
- SPI/DSP-Compatible Serial Interface
- Single Supply: 2.7 Vdc to 5.5 Vdc
- Rail-to-Rail Analog Input With 500 kHz BW
- Three Options Available:
  - TLV2541: Single Channel Input
  - TLV2542: Dual Channels With Autosweep
  - TLV2545: Single Channel With Pseudo-Differential Input
- Low Power With Autopower Down
  - Operating Current: 1 mA at 2.7 V, 1.5 mA at 5 V
  - Autopower Down: 2  $\mu$ A at 2.7 V, 5  $\mu$ A at 5 V
- Small 8-Pin MSOP and SOIC Packages



## description

The TLV2541, TLV2542, and TLV2545 are a family of high performance, 12-bit, low power, miniature, CMOS analog-to-digital converters (ADC). The TLV254x family operates from a single 2.7-V to 5.5-V supply. Devices are available with single, dual, or single pseudo-differential inputs. Each device has a chip select ( $\overline{CS}$ ), serial clock (SCLK), and serial data output (SDO) that provides a direct 3-wire interface to the serial port of most popular host microprocessors (SPI interface). When interfaced with a TMS320™ DSP, a frame sync signal (FS) can be used to indicate the start of a serial data frame on  $\overline{CS}$  for all devices or FS for the TLV2541.

TLV2541, TLV2542, and TLV2545 are designed to operate with very low power consumption. The power saving feature is further enhanced with an autopower-down mode. This product family features a high-speed serial link to modern host processors with SCLK up to 20 MHz. The maximum SCLK frequency is dependent upon the mode of operation (see Table 1). The TLV254x family uses the built-in oscillator as the conversion clock, providing a 3.5- $\mu$ s conversion time.

### AVAILABLE OPTIONS

T <sub>A</sub>	PACKAGED DEVICES	
	8-MSOP (DGK)	8-SOIC (D)
0°C to 70°C	TLV2541CDGK (AGZ)	
	TLV2542CDGK (AHB)	
	TLV2545CDGK (AHD)	
–40°C to 85°C	TLV2541IDGK (AHA)	TLV2541ID
	TLV2542IDGK (AHC)	TLV2542ID
	TLV2545IDGK (AHE)	TLV2545ID



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PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.



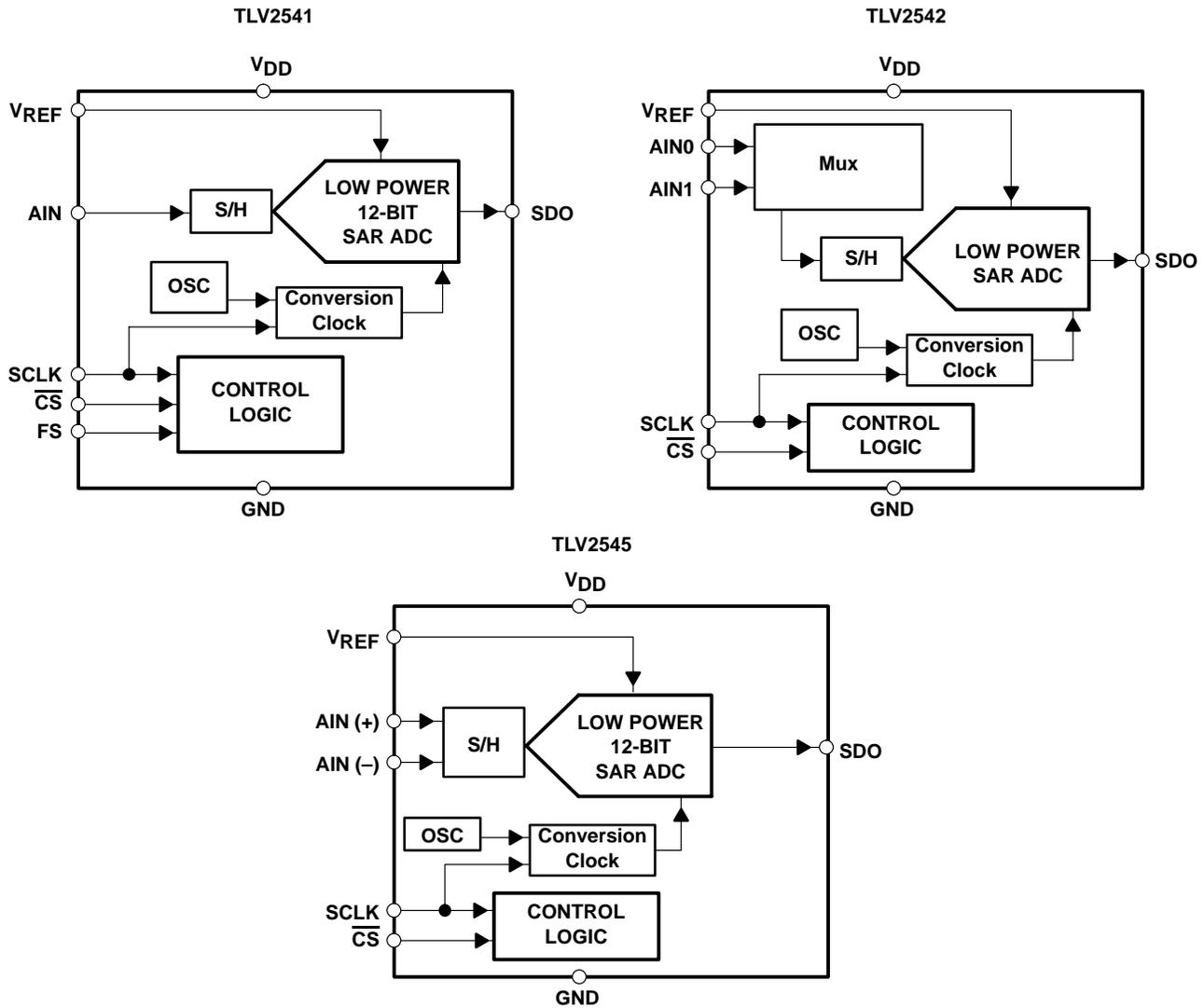
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**TLV2541, TLV2542, TLV2545**  
**2.7-V TO 5.5-V, LOW-POWER, 12-BIT, 140/200 KSPS,**  
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**functional block diagram**



TLV2541, TLV2542, TLV2545  
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### Terminal Functions

#### TLV2541

TERMINAL		I/O	DESCRIPTION
NAME	NO.		
AIN	4	I	Analog input channel
$\overline{\text{CS}}$	1	I	Chip select. A high-to-low transition on the $\overline{\text{CS}}$ input removes SDO from 3-state within a maximum setup time. $\overline{\text{CS}}$ can be used as the FS pin when a dedicated DSP serial port is used.
FS	7	I	DSP frame sync input. Indication of the start of a serial data frame. Tie this terminal to $V_{\text{DD}}$ if not used.
GND	3	I	Ground return for the internal circuitry. Unless otherwise noted, all voltage measurements are with respect to GND.
SCLK	5	I	Output serial clock. This terminal receives the serial SCLK from the host processor.
SDO	8	O	The 3-state serial output for the A/D conversion result. SDO is kept in the high-impedance state until $\overline{\text{CS}}$ falling edge or FS rising edge, whichever occurs first. The output format is MSB first.  When FS is not used ( $\text{FS} = 1$ at the falling edge of $\overline{\text{CS}}$ ): The MSB is presented to the SDO pin after $\overline{\text{CS}}$ falling edge and output data is valid on the first falling edge of SCLK.  When $\overline{\text{CS}}$ and FS are both used ( $\text{FS} = 0$ at the falling edge of $\overline{\text{CS}}$ ): The MSB is presented to the SDO pin after the falling edge of $\overline{\text{CS}}$ . When $\overline{\text{CS}}$ is tied/held low, the MSB is presented on SDO after the rising FS. Output data is valid on the first falling edge of SCLK. (This is typically used with an active FS from a DSP using a dedicated serial port.)
$V_{\text{DD}}$	6	I	Positive supply voltage
$V_{\text{REF}}$	2	I	External reference input

#### TLV2542/45

TERMINAL		I/O	DESCRIPTION
NAME	NO.		
AIN0 /AIN(+)	4	I	Analog input channel 0 for TLV2542—Positive input for TLV2545.
AIN1/AIN (-)	5	I	Analog input channel 1 for TLV2542—Inverted input for TLV2545.
$\overline{\text{CS}}$	1	I	Chip select. A high-to-low transition on $\overline{\text{CS}}$ removes SDO from 3-state within a maximum delay time. This pin can be connected to the frame sync of a DSP using a dedicated serial port.
GND	3	I	Ground return for the internal circuitry. Unless otherwise noted, all voltage measurements are with respect to GND.
SCLK	7	I	Output serial clock. This terminal receives the serial SCLK from the host processor.
SDO	8	O	The 3-state serial output for the A/D conversion result. SDO is kept in the high-impedance state when $\overline{\text{CS}}$ is high and presents output data after the $\overline{\text{CS}}$ falling edge until the LSB is presented. The output format is MSB first. SDO returns to the Hi-Z state after the 16th SCLK. Output data is valid on the falling SCLK edge.
$V_{\text{DD}}$	6	I	Positive supply voltage
$V_{\text{REF}}$	2	I	External reference input

#### detailed description

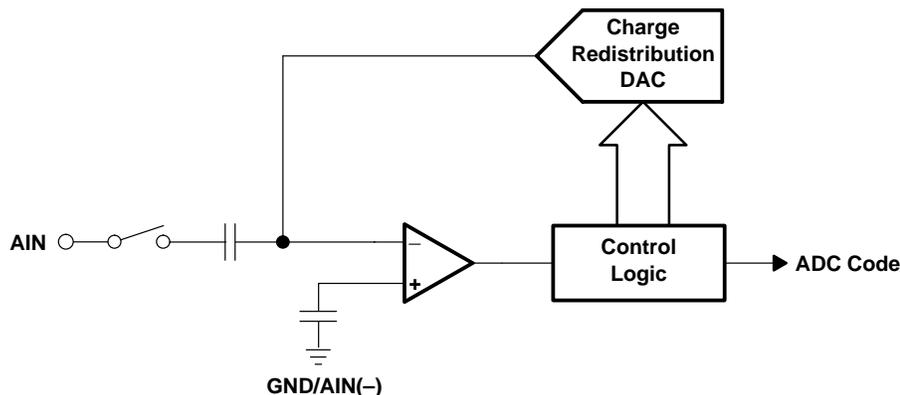
The TLV2541, TLV2542, and TLV2545 are successive approximation (SAR) ADCs utilizing a charge redistribution DAC. Figure 1 shows a simplified version of the ADC.

The sampling capacitor acquires the signal on AIN during the sampling period. When the conversion process starts, the SAR control logic and charge redistribution DAC are used to add and subtract fixed amounts of charge from the sampling capacitor to bring the comparator into a balanced condition. When the comparator is balanced, the conversion is complete and the ADC output code is generated.

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**detailed description (continued)**



**Figure 1. Simplified SAR Circuit**

**serial interface**

OUTPUT DATA FORMAT	
MSB	LSB
D15–D4	D3–D0
Conversion result (OD11–OD0)	Don't care

The output data format is binary (unipolar straight binary).

**binary**

Zero-scale code = 000h,  $V_{code} = GND$   
 Full-scale code = FFFh,  $V_{code} = V_{REF} - 1 \text{ LSB}$

**pseudo-differential inputs**

The TLV2545 operates in pseudo-differential mode. The inverted input is available on pin 5. It can have a maximum input ripple of  $\pm 0.2 \text{ V}$ . This is normally used for ground noise rejection.

**control and timing**

**start of the cycle**

Each cycle may be started by either  $\overline{CS}$ , FS, or a combination of both. The internal state machine requires one SCLK high-to-low transition to determine the state of these control signals so internal blocks can be powered up in an active cycle. Special care to SPI mode is necessary. Make sure there is at least one SCLK whenever  $\overline{CS}$  (pin 1) is high to ensure proper operation.

**TLV2541**

- Control via  $\overline{CS}$  (FS = 1 at the falling edge of  $\overline{CS}$ )—The falling edge of  $\overline{CS}$  is the start of the cycle. The MSB should be read on the first falling SCLK edge after  $\overline{CS}$  is low. Output data changes on the rising edge of SCLK. This is typically used for a microcontroller with an SPI interface, although it can also be used for a DSP. The microcontroller SPI interface should be programmed for CPOL = 0 (serial clock referenced to ground) and CPHA = 1 (data is valid on the falling edge of the serial clock). At least one falling edge transition on SCLK is needed whenever  $\overline{CS}$  is brought high.
- Control via FS ( $\overline{CS}$  is tied/held low)—The MSB is presented after the rising edge of FS. The falling edge of FS is the start of the cycle. The MSB should be read on the first falling edge of SCLK after FS is low. This is the typical configuration when the ADC is the only device on the DSP serial port.



### control and timing (continued)

- Control via both  $\overline{CS}$  and FS—The MSB is presented after the falling edge of  $\overline{CS}$ . The falling edge of FS is the start of the sampling cycle. The MSB should be read on the first falling SCLK edge after FS is low. Output data changes on the rising edge of SCLK. This configuration is typically used for multiple devices connected to a TMS320 DSP.

#### TLV2542/5

All control is provided using  $\overline{CS}$  (pin 1) on the TLV2542 and TLV2545. The cycle is started on the falling edge transition provided by either a  $\overline{CS}$  signal from an SPI microcontroller or FS signal from a TMS320 DSP. Timing is similar to the TLV2541, with control via  $\overline{CS}$  only.

### TLV2542 channel MUX reset cycle

The TLV2542 uses  $\overline{CS}$  to reset the analog input multiplexer. A short active  $\overline{CS}$  cycle (4 to 7 SCLKs) resets the MUX to AIN0. When the  $\overline{CS}$  cycle time is greater than 7 SCLKs in duration, as in the case for a complete conversion cycle ( $\overline{CS}$  is low for 16 SCLKs plus maximum conversion time), the MUX toggles to the next channel (see Figure 4 for timing).

### sampling

The converter sample time is 12 SCLKs in duration, beginning on the fifth SCLK received after the converter has received a high-to-low  $\overline{CS}$  transition (or a high-to-low FS transition for the TLV2541).

### conversion

The TLV2541, TLV2542, and TLV2545 complete conversions in the following manner. The conversion is started after the 16th SCLK falling edge and takes 3.5  $\mu$ s to complete. Enough time (for conversion) should be allowed before a rising  $\overline{CS}$  or FS edge so that no conversion is terminated prematurely.

TLV2542 input channel selection is toggled on each rising  $\overline{CS}$  edge. The MUX channel can be reset to AIN0 via  $\overline{CS}$  as described in the earlier section and in Figure 4. The input is sampled for 12 SCLKs, converted, and the result is presented on SDO during the next cycle. Care should also be taken to allow enough time between samples to avoid prematurely terminating the cycle, which occurs on a rising  $\overline{CS}$  transition if the conversion is not complete.

The SDO data presented during a cycle is the result of the conversion of the sample taken during the previous cycle.

### timing diagrams/conversion cycles

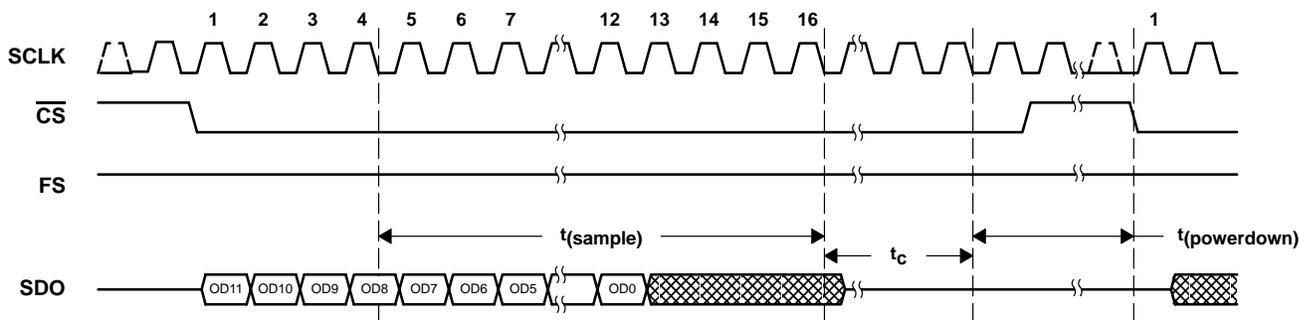
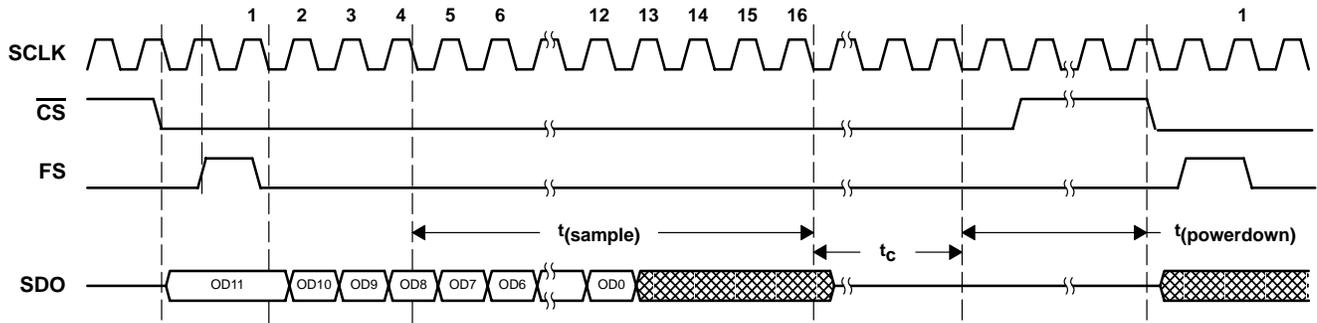


Figure 2. TLV2541 Timing: Control via  $\overline{CS}$  (FS = 1)

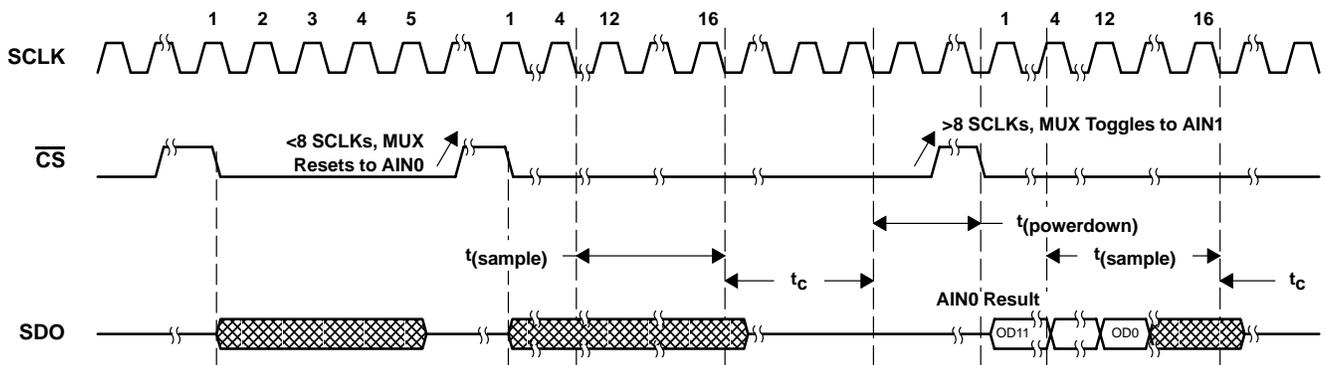
**TLV2541, TLV2542, TLV2545**  
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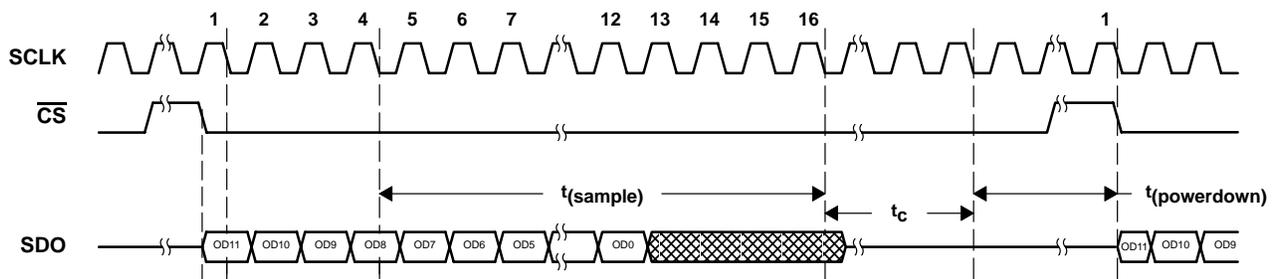
**timing diagrams/conversion cycles (continued)**



**Figure 3. TLV2541 Timing: Control via  $\overline{\text{CS}}$  and FS or FS Only**



**Figure 4. TLV2542 Reset Timing**



**Figure 5. TLV2542 and TLV2545 Timing**

**using  $\overline{\text{CS}}$  as the FS input**

When interfacing the TLV2541 with the TMS320 DSP, the FSR signal from the DSP may be connected to the  $\overline{\text{CS}}$  input if this is the only device on the serial port. This saves one output terminal from the DSP. (Output data changes on the falling edge of SCLK. This is the default configuration for the TLV2542 and TLV2545.)

## using $\overline{\text{CS}}$ as the FS input (continued)

### SCLK and conversion speed

The input frequency of SCLK can range from 100 kHz to 20 MHz maximum. The ADC conversion uses a separate internal oscillator with a minimum frequency of 4 MHz. The conversion cycle takes 14 internal oscillator clocks to complete. This leads to a 3.5- $\mu\text{s}$  conversion time. For a 20-MHz SCLK, the minimum total cycle time is given by:  $16 \times (1/20\text{M}) + 14 \times (1/4\text{M}) + \text{one SCLK} = 4.35 \mu\text{s}$ . An additional SCLK is added to account for the required  $\overline{\text{CS}}$  and/or FS high time. These times specify the minimum cycle time for an active  $\overline{\text{CS}}$  or FS signal. If violated, the conversion terminates, invalidating the next data output cycle. Table 1 gives the maximum SCLK frequency for a given supply voltage and operational mode.

### control via pin 1 ( $\overline{\text{CS}}$ , SPI interface)

All devices are compatible with this mode operation. A falling  $\overline{\text{CS}}$  initiates the cycle (for TLV2541, the FS input is tied to  $V_{\text{DD}}$ ).  $\overline{\text{CS}}$  remains low for the entire cycle time (sample+convert+one SCLK) and can then be released.

**NOTE:**

IMPORTANT: A single SCLK is required whenever  $\overline{\text{CS}}$  is high.

### control via pin 1 ( $\overline{\text{CS}}$ , DSP interface)

All devices are compatible with this mode of operation. The FS signal from a DSP is connected directly to the  $\overline{\text{CS}}$  input of the ADC. A falling edge on the  $\overline{\text{CS}}$  input initiates the cycle. (For the TLV2541, the FS input can be tied to  $V_{\text{DD}}$ , although better performance can be achieved when using the FS input for control. Refer to the next section.) The  $\overline{\text{CS}}$  input should remain low for the entire cycle time (sample+convert+one SCLK) and can then be released.

**NOTE:**

IMPORTANT: A single SCLK is required whenever  $\overline{\text{CS}}$  is high. This should be of little consequence, since SCLK is normally always present when interfacing with a DSP.

### control via pin 1 and pin 7 ( $\overline{\text{CS}}$ and FS or FS only, DSP interface)

Only the TLV2541 is compatible with this mode of operation. The  $\overline{\text{CS}}$  input to the ADC can be controlled via a general-purpose I/O pin from the DSP. The FS signal from the DSP is connected directly to the FS input of the ADC. A falling edge on  $\overline{\text{CS}}$ , if used, releases the MSB on the SDO output. When  $\overline{\text{CS}}$  is not used, the rising FS edge releases the MSB. The falling edge on the FS input while SCLK is high initiates the cycle. The  $\overline{\text{CS}}$  and FS inputs should remain low for the entire cycle time (sample+convert+one SCLK) and can then be released.

### reference voltage

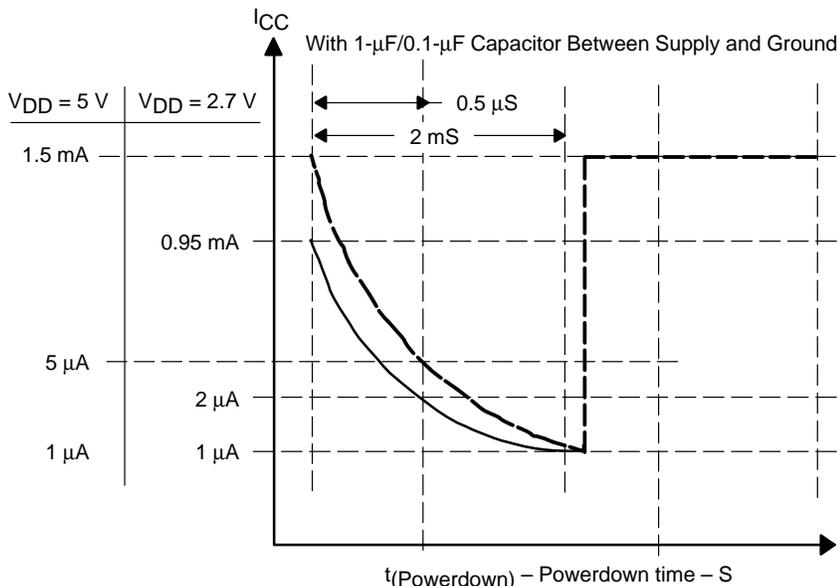
An external reference is applied via  $V_{\text{REF}}$ . The voltage level applied to this pin establishes the upper limit of the analog inputs to produce a full-scale reading. The value of  $V_{\text{REF}}$  and the analog input should not exceed the positive supply or be less than GND, consistent with the specified absolute maximum ratings. The digital output is at full scale when the input signal is equal to or higher than  $V_{\text{REF}}$  and at zero when the input signal is equal to or lower than GND.

### power down and power up

Autopower down is built into these devices in order to reduce power consumption. The actual power savings depends on the inactive time between cycles and the power supply (loading) decoupling/storage capacitors. *Power-down takes effect immediately after the conversion is complete.* This is fast enough to provide some power savings between cycles with longer than 1 SCLK inactive time. *The device power goes down to 5  $\mu\text{A}$  within 0.5  $\mu\text{s}$ .* To achieve the lowest power-down current (*deep powerdown*) of 1  $\mu\text{A}$  requires 2-ms inactive time between cycles. The power-down state is initiated at the end of conversion. These devices wake up *immediately* at the next falling edge of  $\overline{\text{CS}}$  or the rising edge of FS.

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**Table 1. Modes of Operation and Data Throughput**

CONTROL PIN(S)/DEVICE	MAX SCLK (MHz) (50/50 duty cycle)		APPROXIMATE CONVERSION THROUGHPUT (ksp/s)	
	$V_{DD} = 2.7\text{ V}$	$V_{DD} = 4.5\text{ V}$	$V_{DD} = 2.7\text{ V}$	$V_{DD} = 4.5\text{ V}$
$\overline{\text{CS}}$ control only (TLV2541 only)				
For SPI interface†	10	15	175	200
For DSP interface (Use $\overline{\text{CS}}$ as FS)‡	5	8	140	175
$\overline{\text{CS}}$ and FS control (TLV2541 only)§				
DSP interface	15	20	200	200

† See Figure 29(a).

‡ See Figure 29(b).

§ See Figure 29(c).

**absolute maximum ratings over operating free-air temperature (unless otherwise noted)¶**

Supply voltage range, GND to $V_{DD}$	-0.3 V to 6.5 V
Analog input voltage range	-0.3 V to $V_{DD} + 0.3\text{ V}$
Reference input voltage	$V_{DD} + 0.3\text{ V}$
Digital input voltage range	-0.3 V to $V_{DD} + 0.3\text{ V}$
Operating virtual junction temperature range, $T_J$	-40°C to 150°C
Operating free-air temperature range, $T_A$ : C	0°C to 70°C
I	-40°C to 85°C
Storage temperature range, $T_{stg}$	-65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°C

¶ 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.



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**recommended operating conditions**

		MIN	NOM	MAX	UNIT
Supply voltage, $V_{DD}$		2.7	3.3	5.5	V
Positive external reference voltage input, $V_{REFP}$ (see Note 1)		2		$V_{DD}$	V
Analog input voltage (see Note 1)		0		$V_{DD}$	V
High level control input voltage, $V_{IH}$		2.1			V
Low-level control input voltage, $V_{IL}$				0.6	V
Setup time, $\overline{CS}$ falling edge before first SCLK falling edge, $t_{su}(CSL-SCLKL)$	$V_{DD} = REF = 4.5\text{ V}$	40			ns
	$V_{DD} = REF = 2.7\text{ V}$	70			
Hold time, $\overline{CS}$ falling edge after SCLK falling edge, $t_h(SCLKL-CSL)$		5			ns
Delay time, delay from $\overline{CS}$ falling edge to FS rising edge, $t_d(CSL-FSH)$ (TLV2541 only)		0.5		7	SCLKs
Setup time, FS rising edge before SCLK falling edge, $t_{su}(FSH-SCLKL)$ (TLV2541 only)		0.35			SCLKs
Hold time, FS high after SCLK falling edge, $t_h(SCLKL-FSL)$ (TLV2541 only)				0.65	SCLKs
Pulse width $\overline{CS}$ high time, $t_w(H\_CS)$		100			ns
Pulse width FS high time, $t_w(H\_FS)$ (TLV2541 only)		0.75			SCLKs
SCLK cycle time, $V_{DD} = 3.6\text{ V}$ to $2.7\text{ V}$ , $t_c(SCLK)$ (maximum tolerance of 40/60 duty cycle)		90		10000	ns
SCLK cycle time, $V_{DD} = 5.5\text{ V}$ to $4.5\text{ V}$ , $t_c(SCLK)$ (maximum tolerance of 40/60 duty cycle)		50		10000	ns
Pulse width low time, $t_w(L\_SCLK)$		0.4		0.6	SCLK
Pulse width high time, $t_w(H\_SCLK)$		0.4		0.6	SCLK
Hold time, hold from end of conversion to $\overline{CS}$ high, $t_h(EOC-CSH)$ (EOC is internal, indicates end of conversion time, $t_c$ )			0.05		$\mu\text{s}$
Active $\overline{CS}$ cycle time to reset internal MUX to $AIN_0$ , $t_{(reset\ cycle)}$ (TLV2542 only)		4		7	SCLKs
Delay time, delay from $\overline{CS}$ falling edge to SDO valid, $t_d(CSL-SDOV)$	$V_{DD} = REF = 4.5\text{ V}$ , 25-pF load			40	ns
	$V_{DD} = REF = 2.7\text{ V}$ , 25-pF load			70	
Delay time, delay from FS falling edge to SDO valid, $t_d(FSL-SDOV)$ (TLV2541 only)	$V_{DD} = REF = 4.5\text{ V}$ , 25-pF load			1	ns
	$V_{DD} = REF = 2.7\text{ V}$ , 25-pF load			1	
Delay time, delay from SCLK rising edge to SDO valid, $t_d(SCLKH-SDOV)$	$V_{DD} = REF = 4.5\text{ V}$ , 25-pF load			11	ns
	$V_{DD} = REF = 2.7\text{ V}$ , 25-pF load			21	
Delay time, delay from 17th SCLK rising edge to SDO 3-state, $t_d(SCLK17H-SDOZ)$	$V_{DD} = REF = 4.5\text{ V}$ , 25-pF load			30	ns
	$V_{DD} = REF = 2.7\text{ V}$ , 25-pF load			60	
Conversion time, $t_c$	Conversion clock = internal oscillator	2.1	2.6	3.5	$\mu\text{s}$
Sampling time, $t_{(sample)}$	See Note 2	300			ns
Operating free-air temperature, $T_A$	TLV2541/2/5C	0		70	$^{\circ}\text{C}$
	TLV2541/2/5I	-40		85	

- NOTES: 1. Analog input voltages greater than that applied to  $V_{REF}$  convert as all ones (111111111111), while input voltages less than that applied to GND convert as all zeros(000000000000).
2. Minimal  $t_{(sample)}$  is given by  $0.9 \times 50\text{ pF} \times (R_S + 0.5\text{ k}\Omega)$ , where  $R_S$  is the source output impedance.

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**electrical characteristics over recommended operating free-air temperature range,**  
 **$V_{DD} = V_{REF} = 2.7\text{ V to }5.5\text{ V}$  (unless otherwise noted)**

PARAMETER		TEST CONDITIONS	MIN	TYP†	MAX	UNIT	
$V_{OH}$	High-level output voltage	$V_{DD} = 5.5\text{ V}$ , $I_{OH} = -0.2\text{ mA}$ at 30-pF load	2.4			V	
		$V_{DD} = 2.7\text{ V}$ , $I_{OH} = -20\text{ }\mu\text{A}$ at 30-pF load	$V_{DD}-0.2$				
$V_{OL}$	Low-level output voltage	$V_{DD} = 5.5\text{ V}$ , $I_{OL} = 0.8\text{ mA}$ at 30-pF load			0.4	V	
		$V_{DD} = 2.7\text{ V}$ , $I_{OL} = 20\text{ }\mu\text{A}$ at 30-pF load			0.1		
$I_{OZ}$	Off-state output current (high-impedance-state)	$V_O = V_{DD}$	$\overline{CS} = V_{DD}$	1		$\mu\text{A}$	
		$V_O = 0$		-1 -2.5			
$I_{IH}$	High-level input current	$V_I = V_{DD}$	0.005		2.5	$\mu\text{A}$	
$I_{IL}$	Low-level input current	$V_I = 0\text{ V}$	-0.005		2.5	$\mu\text{A}$	
$I_{CC}$	Operating supply current	$\overline{CS}$ at 0 V	$V_{DD} = 4.5\text{ V to }5.5\text{ V}$	1.3		1.5	mA
			$V_{DD} = 2.7\text{ V to }3.3\text{ V}$	0.85		0.95	
$I_{CC}(\text{AUTOPWDN})$	Autopower-down current $t(\text{powerdown}) \geq 0.5\text{ }\mu\text{s}$	For all digital inputs, $0 \leq V_I \leq 0.3\text{ V}$ or $V_I \geq V_{DD} - 0.3\text{ V}$ , SCLK = 0, $V_{DD} = 4.5\text{ V to }5.5\text{ V}$ , Ext ref				5	$\mu\text{A}$
		$V_{DD} = 2.7\text{ V to }3.3\text{ V}$ , Ext ref				2	
	Deep autopower-down current $t(\text{powerdown}) \geq 2\text{ ms}$	For all digital inputs, $0 \leq V_I \leq 0.3\text{ V}$ or $V_I \geq V_{DD} - 0.3\text{ V}$ , SCLK = 0, $V_{DD} = 4.5\text{ V to }5.5\text{ V}$ , Ext ref				1	$\mu\text{A}$
		$V_{DD} = 2.7\text{ V to }3.3\text{ V}$				1	
Selected analog input channel leakage current		Selected channel at $V_{DD}$				1	$\mu\text{A}$
		Selected channel at 0 V				-1	
$C_i$	Input capacitance	Analog inputs		20	45	50	pF
		Control Inputs		5		25	
Input on resistance		$V_{DD} = 5.5\text{ V}$				500	$\Omega$
		$V_{DD} = 2.7\text{ V}$				600	
Autopower down				0.5		SCLK	

† All typical values are at  $V_{DD} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$ .



**TLV2541, TLV2542, TLV2545**  
**2.7-V TO 5.5-V, LOW-POWER, 12-BIT, 140/200 KSPS,**  
**SERIAL ANALOG-TO-DIGITAL CONVERTERS WITH AUTOPOWER DOWN**

SLAS245D – MARCH 2000 – REVISED MAY 2003

**ac specifications (f<sub>i</sub> = 20 kHz)**

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
SINAD	Signal-to-noise ratio +distortion	200 KSPS, V <sub>DD</sub> = V <sub>REF</sub> = 5.5 V	70	72		dB
		150 KSPS, V <sub>DD</sub> = V <sub>REF</sub> = 2.7 V	68	71		
THD	Total harmonic distortion	200 KSPS, V <sub>DD</sub> = V <sub>REF</sub> = 5.5 V		-84	-80	dB
		150 KSPS, V <sub>DD</sub> = V <sub>REF</sub> = 2.7 V		-84	-80	
ENOB	Effective number of bits	200 KSPS, V <sub>DD</sub> = V <sub>REF</sub> = 5.5 V		11.8		Bits
		150 KSPS, V <sub>DD</sub> = V <sub>REF</sub> = 2.7 V		11.6		
SFDR	Spurious free dynamic range	200 KSPS, V <sub>DD</sub> = V <sub>REF</sub> = 5.5 V		-84	-80	dB
		150 KSPS, V <sub>DD</sub> = V <sub>REF</sub> = 2.7 V		-84	-80	
<b>Analog Input</b>						
	Full-power bandwidth, -3 dB			1		MHz
	Full-power bandwidth, -1 dB			500		kHz

**external reference specifications**

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
	Reference input voltage	V <sub>DD</sub> = 2.7 V to 5.5 V	2		V <sub>DD</sub>	V
Reference input impedance	V <sub>DD</sub> = 5.5 V	$\overline{\text{CS}} = 1, \text{ SCLK} = 0$	100			MΩ
		$\overline{\text{CS}} = 0, \text{ SCLK} = 20 \text{ MHz}$	20	25		kΩ
	V <sub>DD</sub> = 2.7 V	$\overline{\text{CS}} = 1, \text{ SCLK} = 0$	100			MΩ
		$\overline{\text{CS}} = 0, \text{ SCLK} = 20 \text{ MHz}$	20	25		kΩ
Reference current	V <sub>DD</sub> = V <sub>REF</sub> = 5.5 V, $\overline{\text{CS}} = 0, \text{ SCLK} = 20 \text{ MHz}$		100	400		μA
	V <sub>DD</sub> = V <sub>REF</sub> = 2.7 V, $\overline{\text{CS}} = 0, \text{ SCLK} = 20 \text{ MHz}$		50	200		
Reference input capacitance	V <sub>DD</sub> = V <sub>REF</sub> = 5.5 V	$\overline{\text{CS}} = 1, \text{ SCLK} = 0$	5		15	pF
		$\overline{\text{CS}} = 0, \text{ SCLK} = 20 \text{ MHz}$	20	45	50	
	V <sub>DD</sub> = V <sub>REF</sub> = 2.7 V	$\overline{\text{CS}} = 1, \text{ SCLK} = 0$	5		15	
		$\overline{\text{CS}} = 0, \text{ SCLK} = 20 \text{ MHz}$	20	45	50	
V <sub>REF</sub>	Reference voltage	V <sub>DD</sub> = 2.7 V to 5.5 V			V <sub>DD</sub>	V

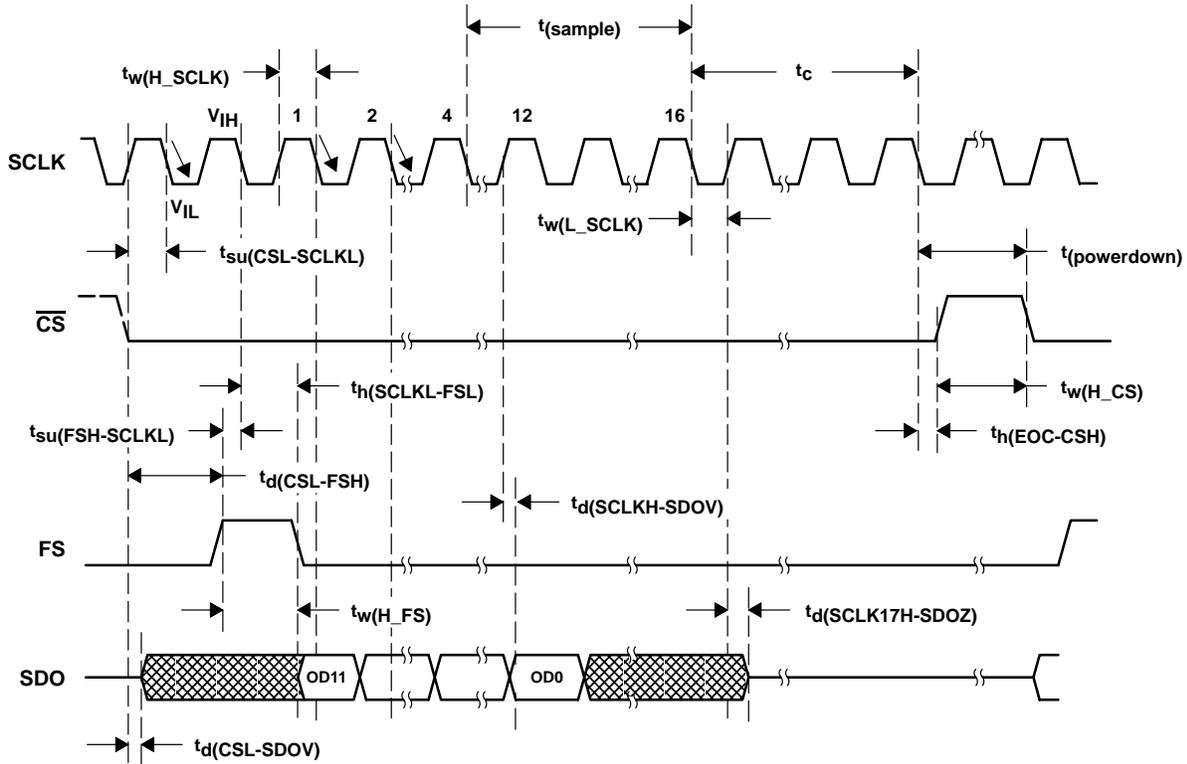
**dc specification, V<sub>DD</sub> = V<sub>REF</sub> = 2.7 V to 5.5 V, SCLK frequency = 20 MHz at 5 V, 15 MHz at 3 V (unless otherwise noted)**

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
INL	Integral linearity error (see Note 4)			±0.6	±1	LSB
DNL	Differential linearity error	See Note 3		±0.5	±1	LSB
E <sub>O</sub>	Offset error (see Note 5)	See Note 3	TLV2541/42		±1.5	LSB
			TLV2545		±2.5	
E <sub>G</sub>	Gain error (see Note 5)	See Note 3	TLV2541/42		±2	LSB
			TLV2545		±5	
E <sub>t</sub>	Total unadjusted error (see Note 6)	See Note 3	TLV2541/42		±2	LSB
			TLV2545		±5	

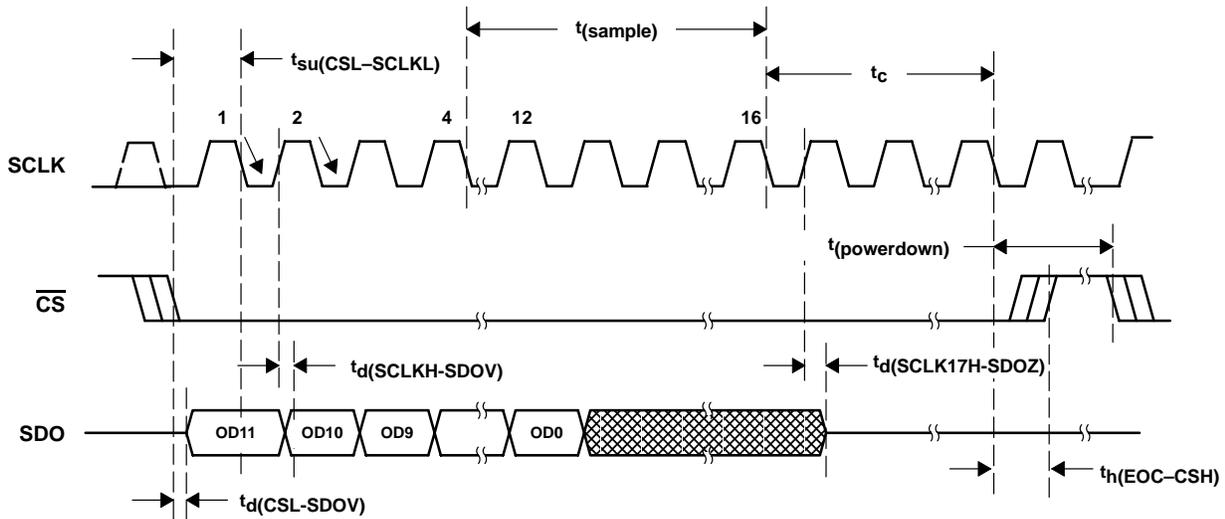
- NOTES: 3. Analog input voltages greater than that applied to V<sub>REF</sub> convert as all ones (111111111111).  
4. Linear error is the maximum deviation from the best straight line through the A/D transfer characteristics.  
5. Zero error is the difference between 000000000000 and the converted output for zero input voltage: full-scale error is the difference between 111111111111 and the converted output for full-scale input voltage.  
6. Total unadjusted error comprises linearity, zero, and full-scale errors.



**PARAMETER MEASUREMENT INFORMATION**

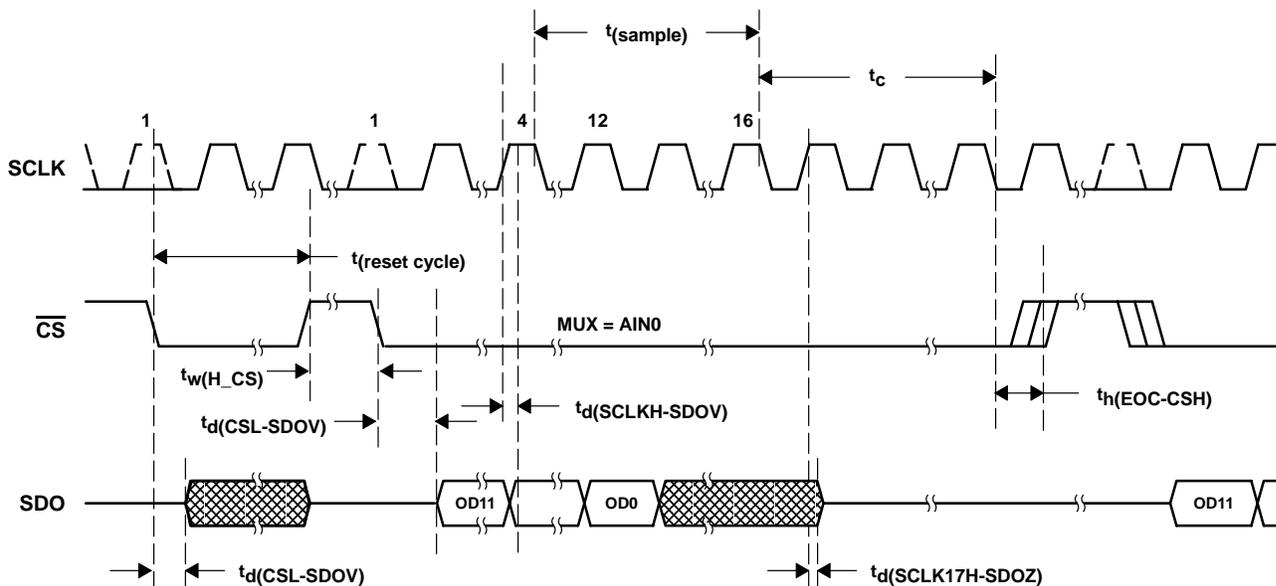


**Figure 6. TLV2541 Critical Timing (Control via  $\overline{CS}$  and FS or FS only)**

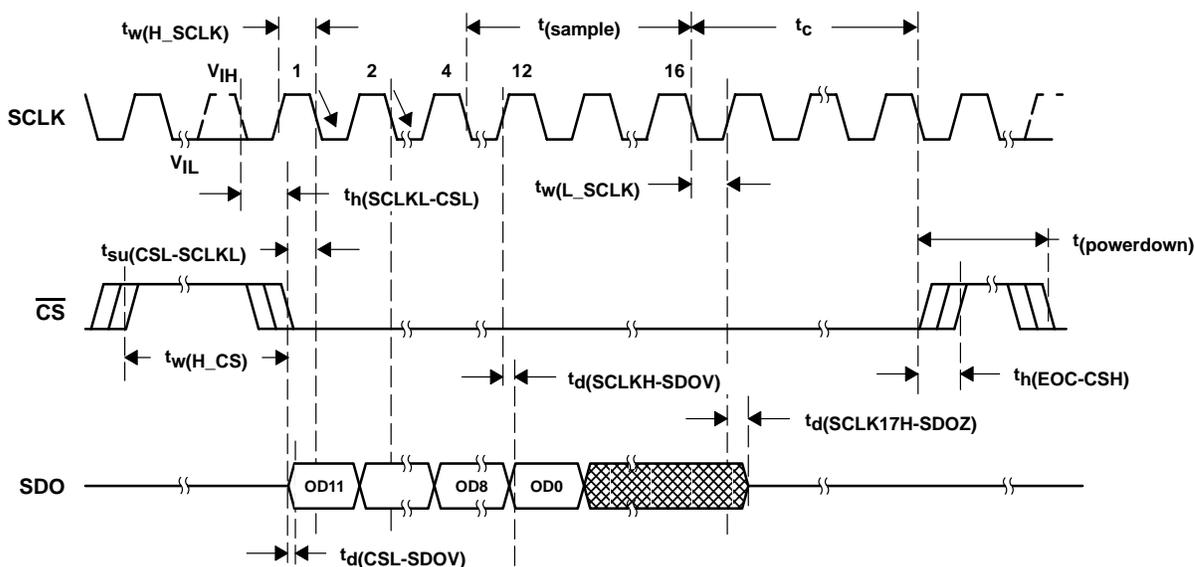


**Figure 7. TLV2541 Critical Timing (Control via  $\overline{CS}$  only, FS = 1)**

**PARAMETER MEASUREMENT INFORMATION**



**Figure 8. TLV2542 Reset Cycle Critical Timing**



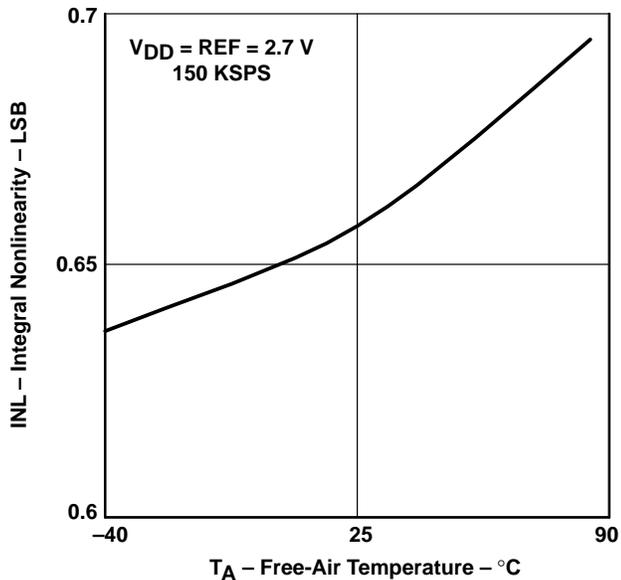
**Figure 9. TLV2542 and TLV2545 Conversion Cycle Critical Timing**

**TLV2541, TLV2542, TLV2545**  
**2.7-V TO 5.5-V, LOW-POWER, 12-BIT, 140/200 KSPS,**  
**SERIAL ANALOG-TO-DIGITAL CONVERTERS WITH AUTOPOWER DOWN**

SLAS245D – MARCH 2000 – REVISED MAY 2003

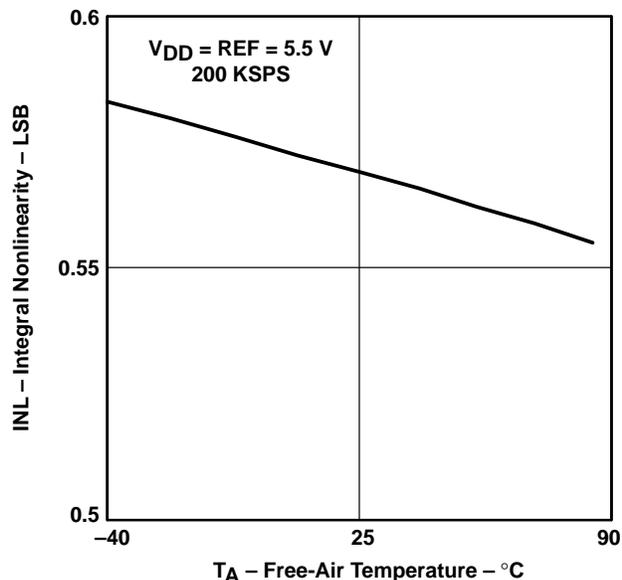
**TYPICAL CHARACTERISTICS**

**INTEGRAL NONLINEARITY**  
**vs**  
**FREE-AIR TEMPERATURE**



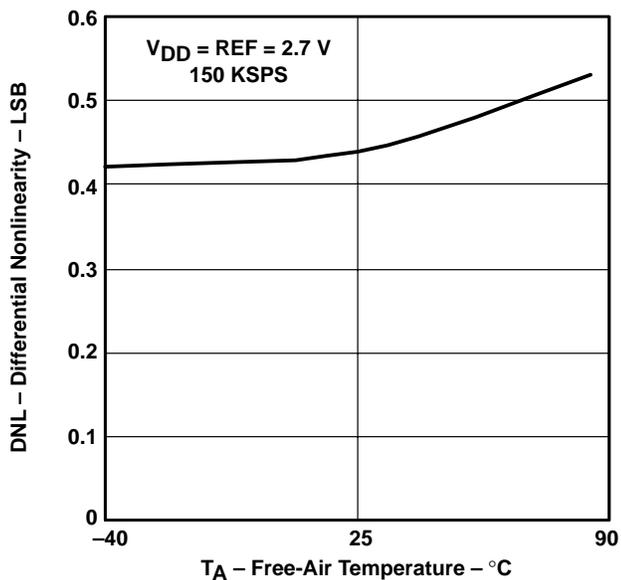
**Figure 10**

**INTEGRAL NONLINEARITY**  
**vs**  
**FREE-AIR TEMPERATURE**



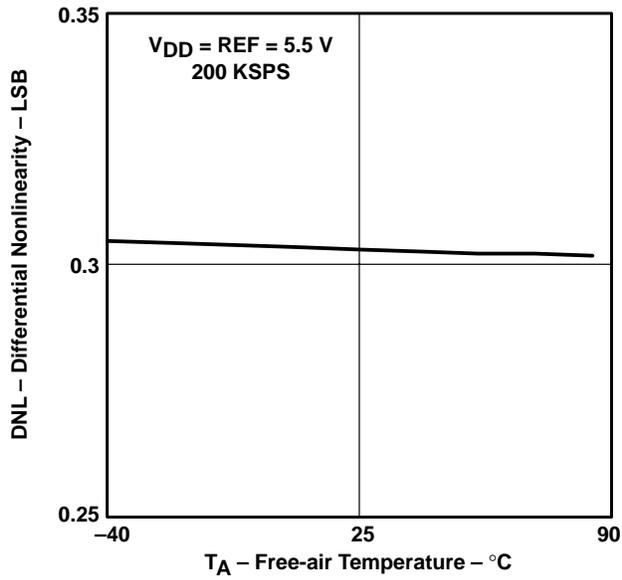
**Figure 11**

**DIFFERENTIAL NONLINEARITY**  
**vs**  
**FREE-AIR TEMPERATURE**



**Figure 12**

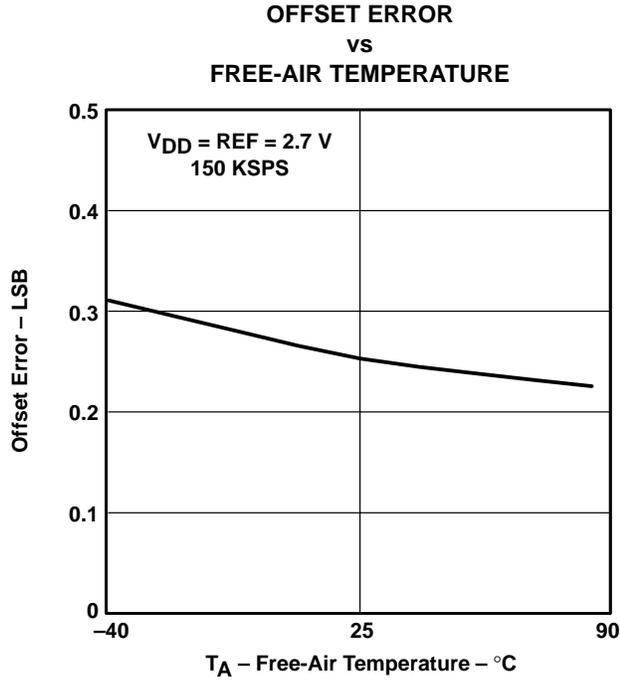
**DIFFERENTIAL NONLINEARITY**  
**vs**  
**FREE-AIR TEMPERATURE**



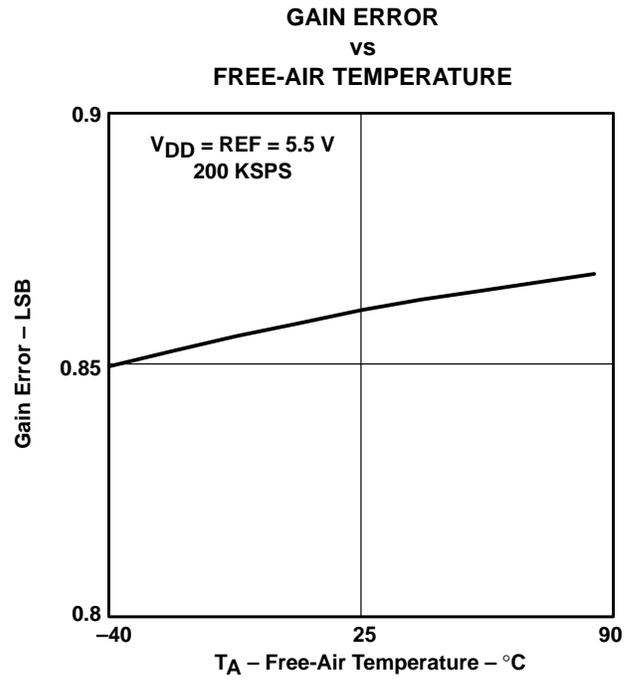
**Figure 13**



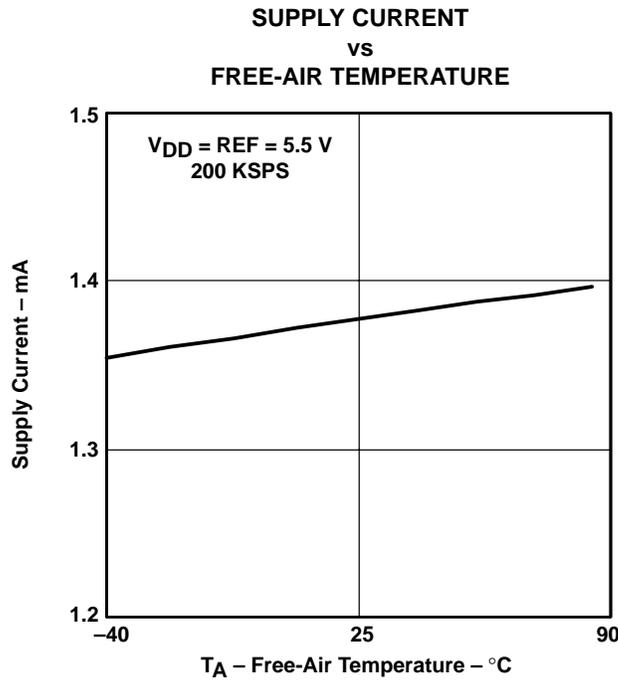
**TYPICAL CHARACTERISTICS**



**Figure 14**



**Figure 15**



**Figure 16**

TYPICAL CHARACTERISTICS

INTEGRAL NONLINEARITY ERROR  
vs  
DIGITAL OUTPUT CODES

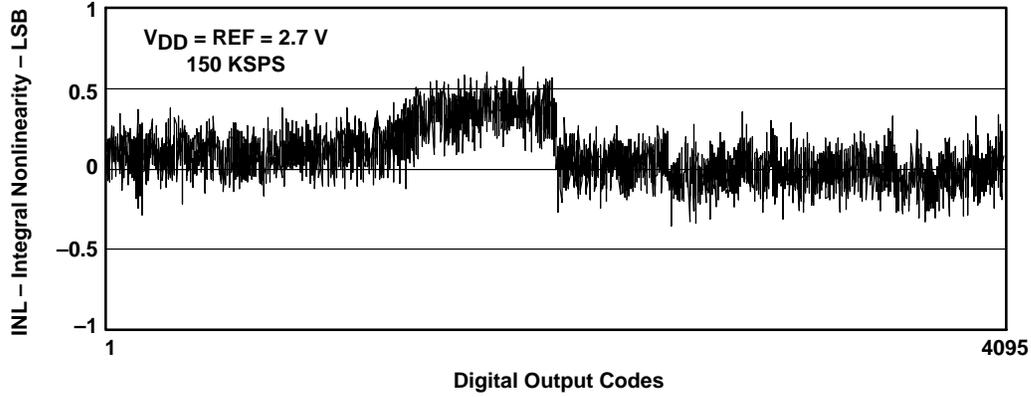


Figure 17

DIFFERENTIAL NONLINEARITY ERROR  
vs  
DIGITAL OUTPUT CODES

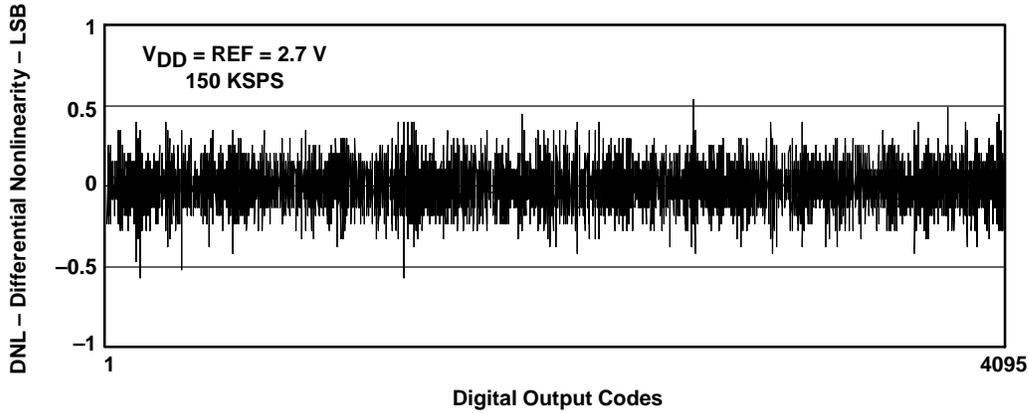


Figure 18

TYPICAL CHARACTERISTICS

INTEGRAL NONLINEARITY ERROR  
vs  
DIGITAL OUTPUT CODES

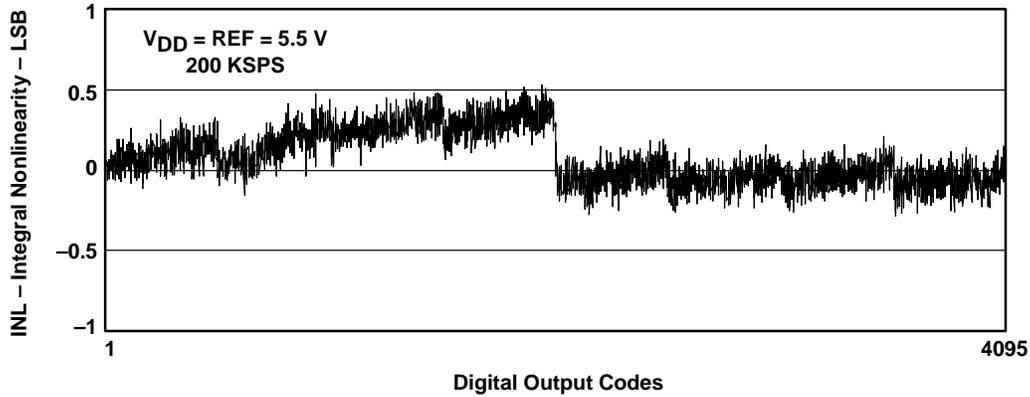


Figure 19

DIFFERENTIAL NONLINEARITY ERROR  
vs  
DIGITAL OUTPUT CODES

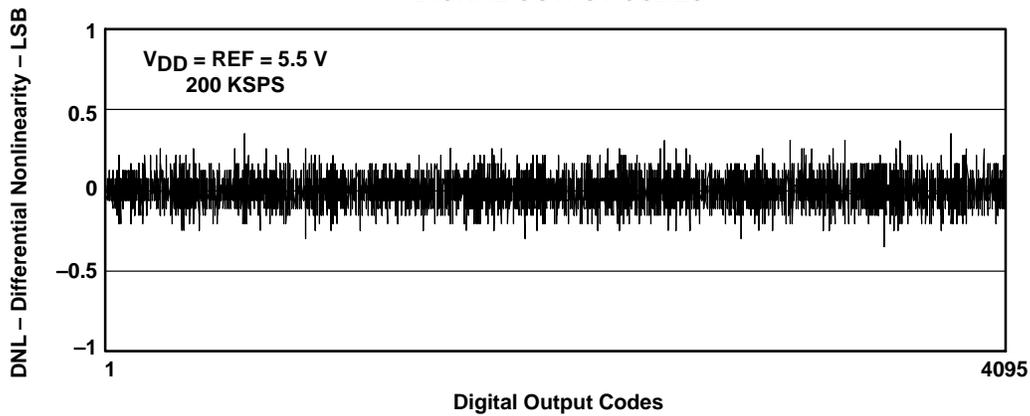


Figure 20

TYPICAL CHARACTERISTICS

2048 POINTS FAST FOURIER TRANSFORM (FFT)

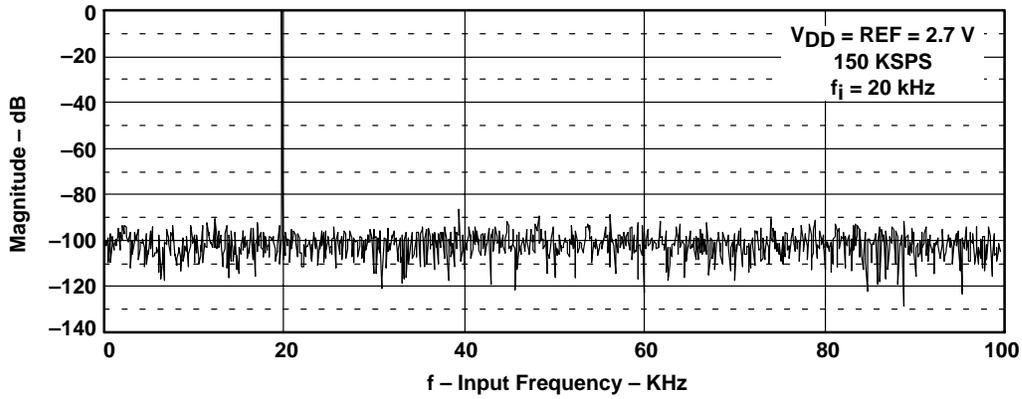


Figure 21

2048 POINTS FAST FOURIER TRANSFORM (FFT)

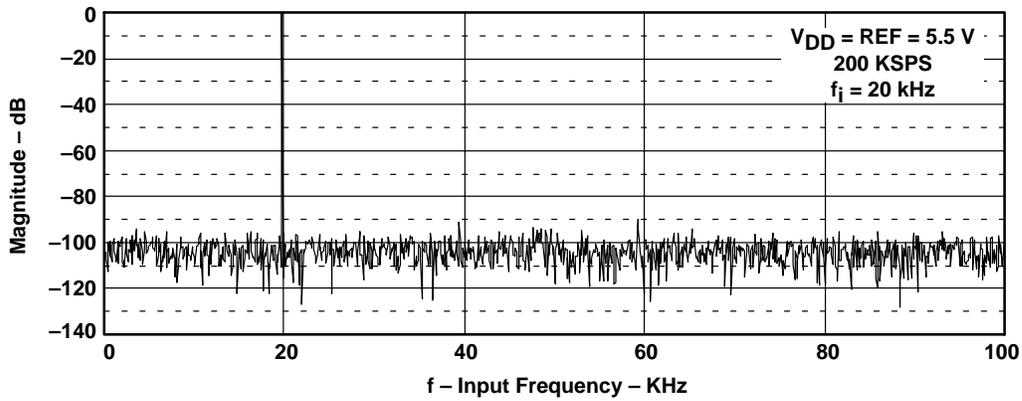
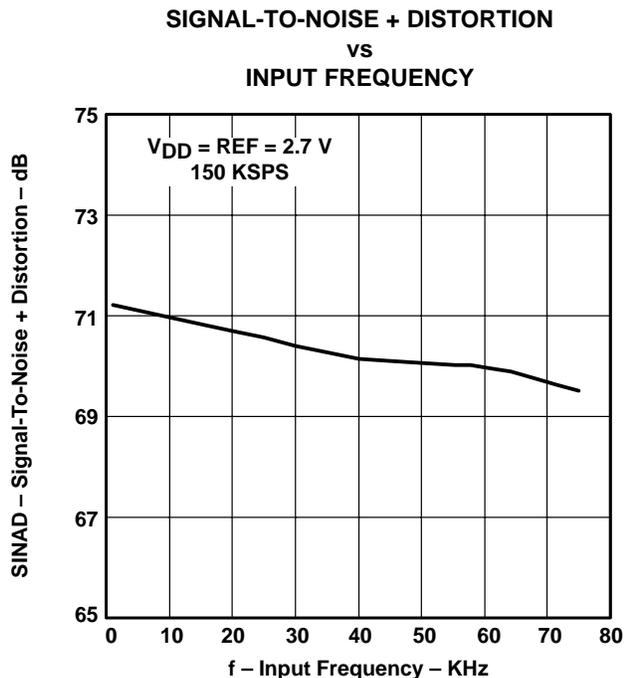
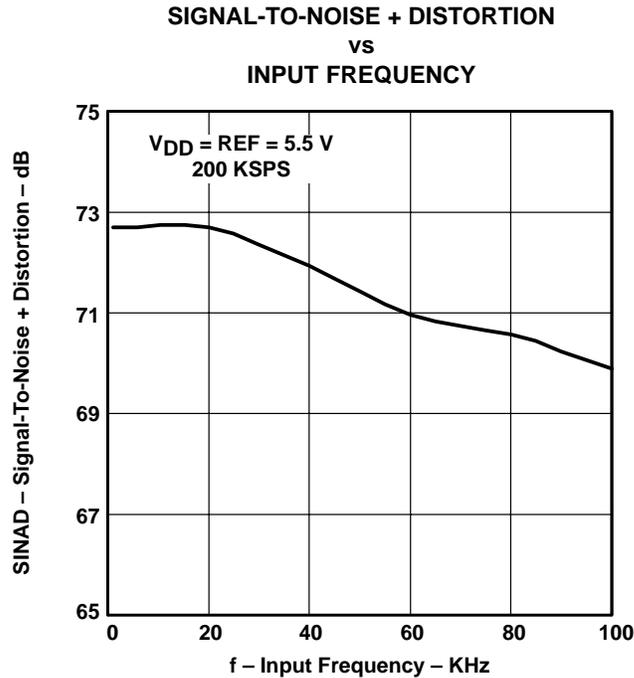


Figure 22

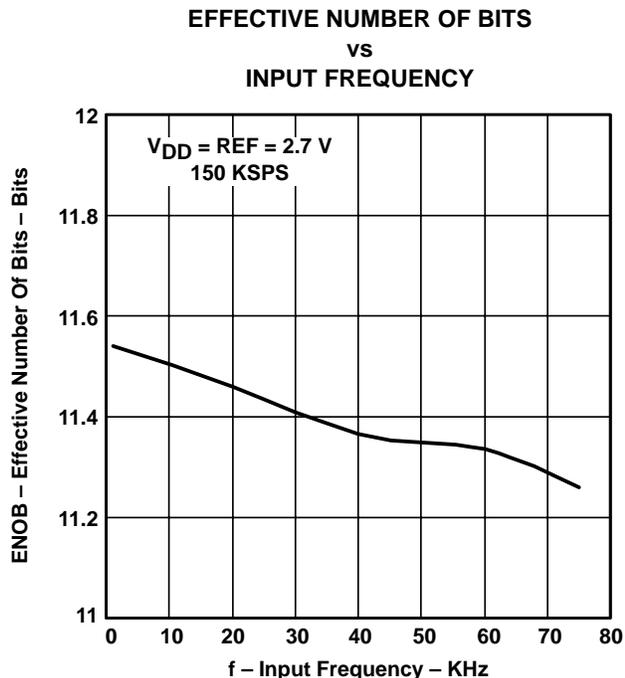
**TYPICAL CHARACTERISTICS**



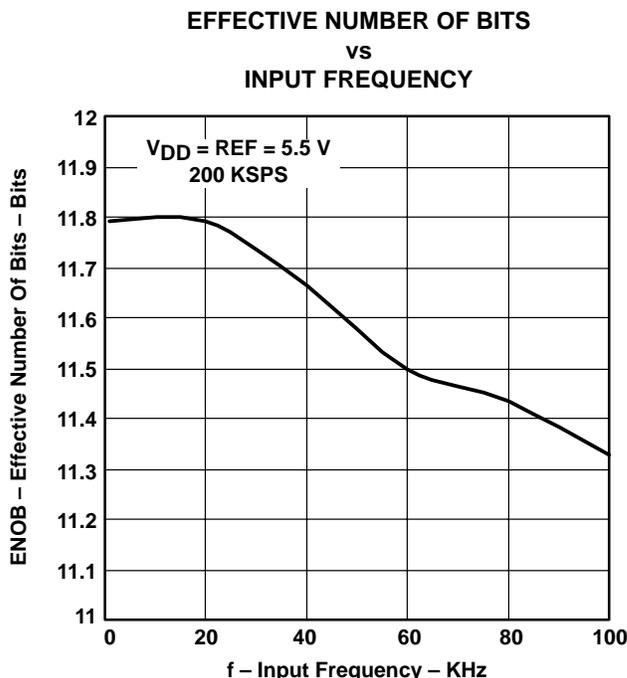
**Figure 23**



**Figure 24**



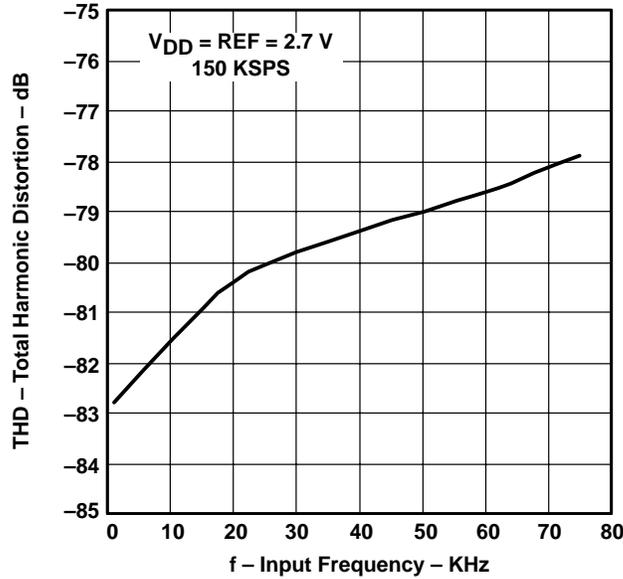
**Figure 25**



**Figure 26**

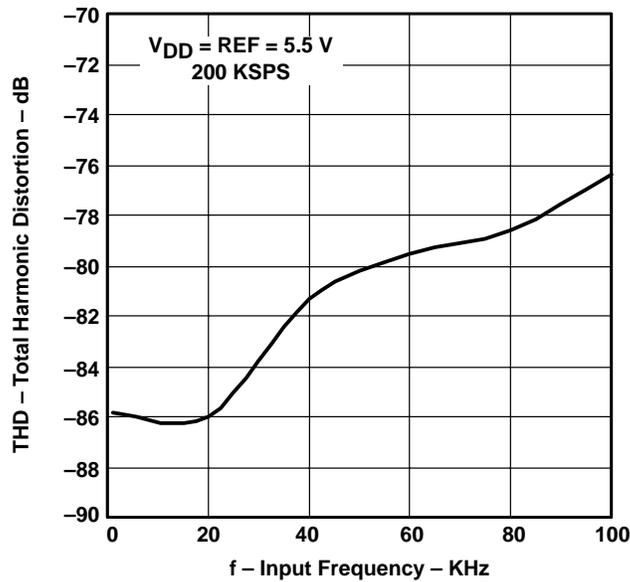
**TYPICAL CHARACTERISTICS**

**TOTAL HARMONIC DISTORTION  
 vs  
 INPUT FREQUENCY**



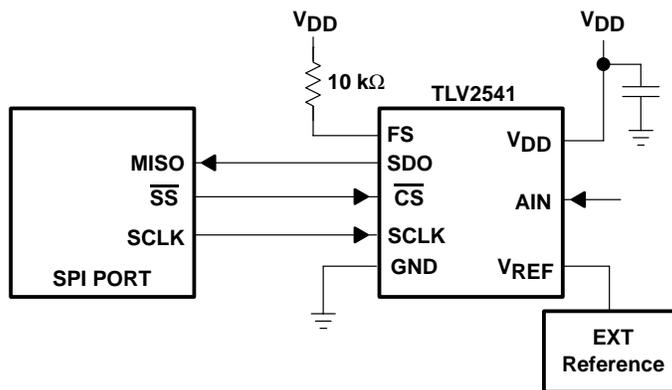
**Figure 27**

**TOTAL HARMONIC DISTORTION  
 vs  
 INPUT FREQUENCY**

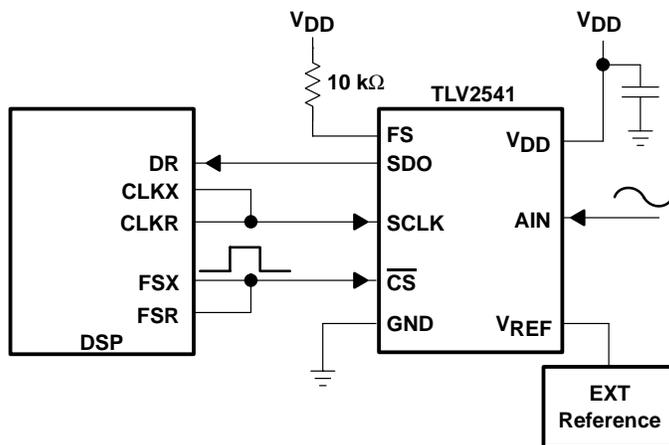


**Figure 28**

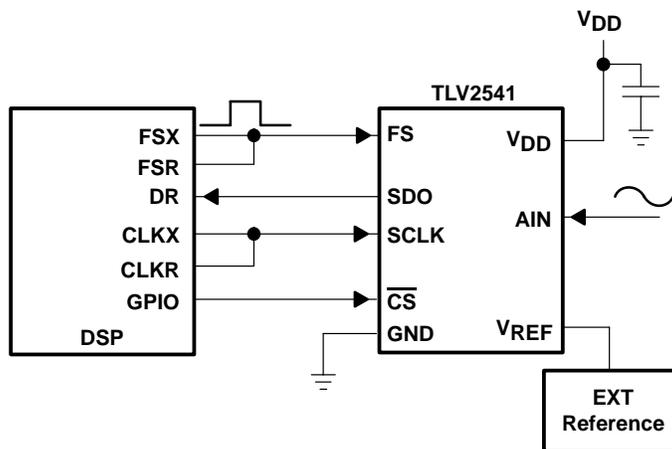
**APPLICATION INFORMATION**



(a)



(b)

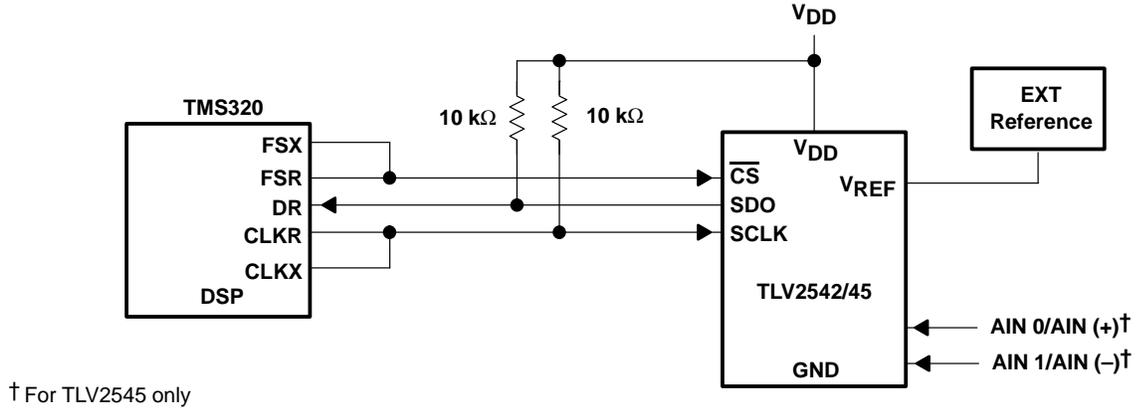


(c)

**Figure 29. Typical TLV2541 Interface to a TMS320 DSP**

**TLV2541, TLV2542, TLV2545**  
**2.7-V TO 5.5-V, LOW-POWER, 12-BIT, 140/200 KSPS,**  
**SERIAL ANALOG-TO-DIGITAL CONVERTERS WITH AUTOPOWER DOWN**  
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**APPLICATION INFORMATION**



**Figure 30. Typical TLV2542/45 Interface to a TMS320 DSP**

**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
TLV2541CDGK	ACTIVE	MSOP	DGK	8	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2541CDGKG4	ACTIVE	MSOP	DGK	8	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2541CDGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2541CDGKRG4	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2541ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2541IDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2541IDGK	ACTIVE	MSOP	DGK	8	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2541IDGKG4	ACTIVE	MSOP	DGK	8	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2541IDGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2541IDGKRG4	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2541IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2541IDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2542CDGK	ACTIVE	MSOP	DGK	8	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2542CDGKG4	ACTIVE	MSOP	DGK	8	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2542CDGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2542CDGKRG4	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2542ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2542IDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2542IDGK	ACTIVE	MSOP	DGK	8	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2542IDGKG4	ACTIVE	MSOP	DGK	8	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2542IDGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2542IDGKRG4	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2542IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2542IDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2545CDGK	ACTIVE	MSOP	DGK	8	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
TLV2545CDGKG4	ACTIVE	MSOP	DGK	8	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2545CDGKRG4	ACTIVE	MSOP	DGK	8		TBD	Call TI	Call TI
TLV2545ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2545IDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2545IDGK	ACTIVE	MSOP	DGK	8	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2545IDGKG4	ACTIVE	MSOP	DGK	8	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2545IDGKRG4	ACTIVE	MSOP	DGK	8		TBD	Call TI	Call TI
TLV2545IDRG4	ACTIVE	SOIC	D	8		TBD	Call TI	Call TI

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

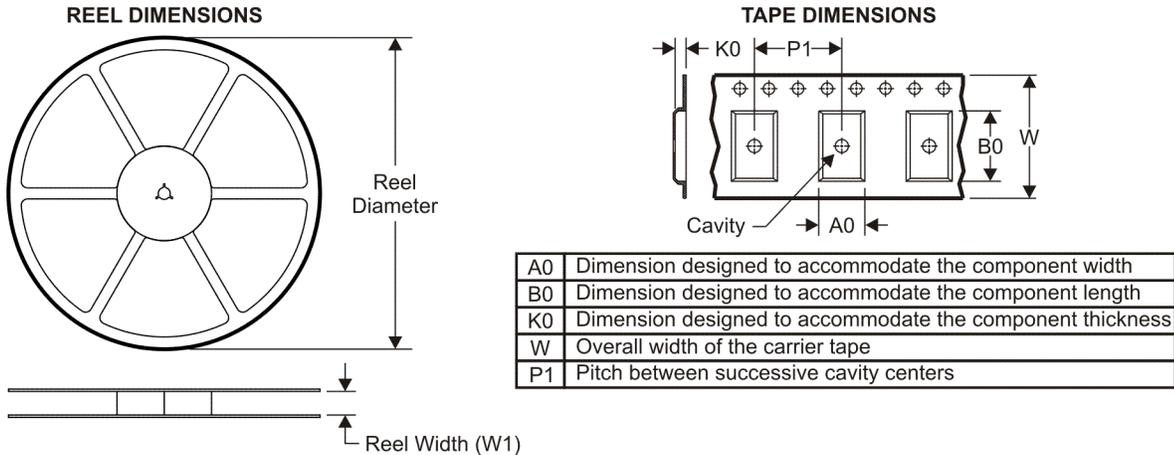
**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

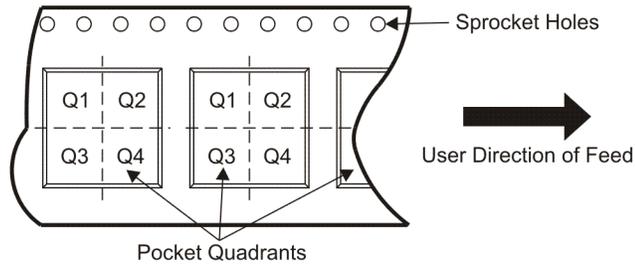
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**TAPE AND REEL INFORMATION**



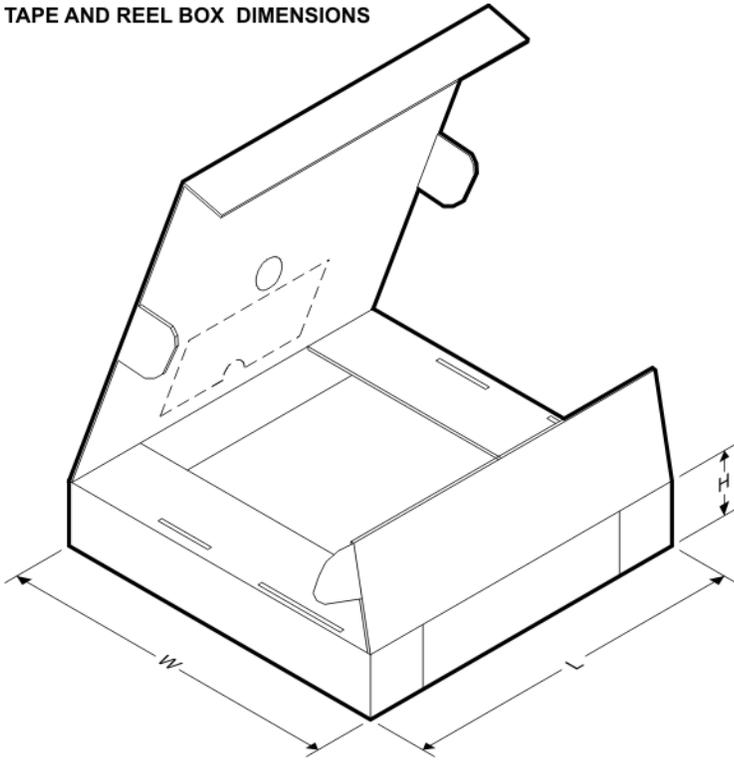
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**



\*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
TLV2541CDGKR	MSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
TLV2541IDGKR	MSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
TLV2541IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TLV2542CDGKR	MSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
TLV2542IDGKR	MSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
TLV2542IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

**TAPE AND REEL BOX DIMENSIONS**



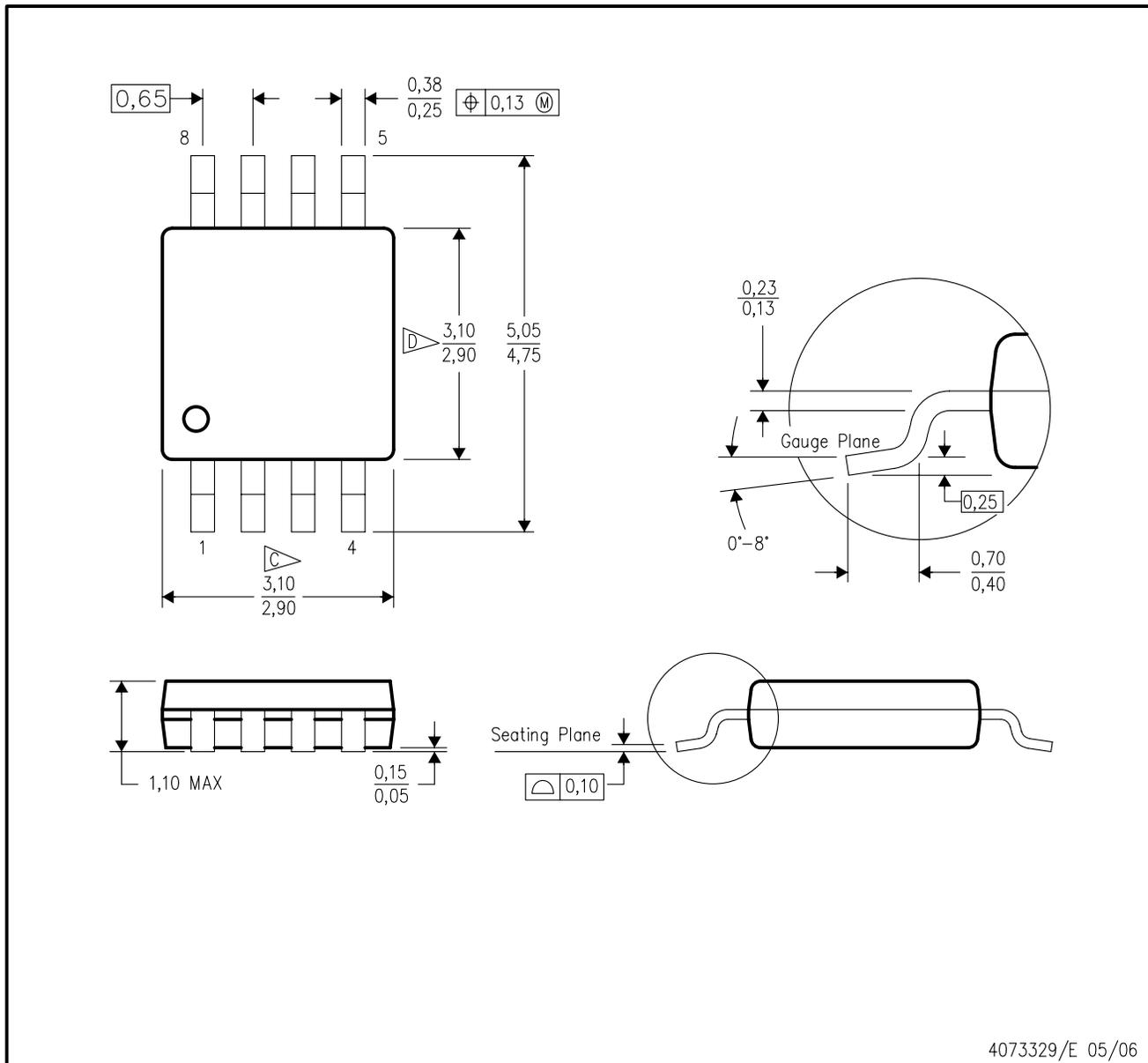
\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TLV2541CDGKR	MSOP	DGK	8	2500	346.0	346.0	29.0
TLV2541IDGKR	MSOP	DGK	8	2500	346.0	346.0	29.0
TLV2541IDR	SOIC	D	8	2500	346.0	346.0	29.0
TLV2542CDGKR	MSOP	DGK	8	2500	346.0	346.0	29.0
TLV2542IDGKR	MSOP	DGK	8	2500	346.0	346.0	29.0
TLV2542IDR	SOIC	D	8	2500	346.0	346.0	29.0



DGK (S-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 per end.
  - D. Body width does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
  - E. Falls within JEDEC MO-187 variation AA, except interlead flash.

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