

# Glossary of Isolation Amplifier Terms

## Outline

This application note provides the definitions of electrical characteristics of isolation amplifiers (analog output: TLP7820 and TLP7920, digital output: TLP7830 and TLP7930), which are a type of photocouplers.

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1. Electrical characteristics of analog-output isolation amplifiers

1.1 DC characteristics

Term	Symbol	Description	Characteristics Curve
Input offset voltage	$V_{OS}$	The converted offset voltage obtained by dividing the $V_{OUT+}-V_{OUT-}$ at $V_{IN}$ of 0V by the gain (G) with negative coefficient. (Intercept on the $V_{IN}$ axis in the $V_{IN}-(V_{OUT+}-V_{OUT-})$ curve) $V_{OS} = -\{(V_{OUT+}-V_{OUT-}) / (\text{Gain } G)\}$ $V_{IN}(V_{IN+}-V_{IN-})$ : differential input voltage $V_{OUT+}-V_{OUT-}$ : differential output voltage	
Input offset voltage drift vs ambient temperature	$ dV_{OS}/dT_a $	The temperature coefficient of the input offset voltage variations (from maximum to minimum value) in ambient temperature range.	
Input offset voltage drift vs input side supply voltage	$ dV_{OS}/dV_{DD1} $	The voltage dependency coefficient of the input offset voltage variations (from maximum to minimum value) in input side supply voltage range.	
Gain	G	The slope (rate of change) of the straight line that approximates the $V_{IN}-(V_{OUT+}-V_{OUT-})$ curve. G is specified over the $V_{IN}$ range between -0.2 and +0.2 V. $V_{IN}(V_{IN+}-V_{IN-})$ : differential input voltage $V_{OUT+}-V_{OUT-}$ : differential output voltage	
Gain drift vs ambient temperature	$ dG/dT_a $	The temperature coefficient of the gain variations (from maximum to minimum value) in ambient temperature range.	
$V_{OUT}$ non-linearity ( $\pm 200$ mV)	$NL_{200}$	The ratio of the sum of the maximum deviations in the positive and negative directions (dev_max and dev_min) of the measured points from the approximate straight line of $V_{IN}-(V_{OUT+}-V_{OUT-})$ curve to the full-scale differential output voltage ( $\{2 * (V_{OH}-V_{OL})\}$ ). $NL_{200}$ is specified over the $V_{IN}$ range between -0.2 and +0.2 V. $NL_{200} = ( dev\_max  +  dev\_min ) / \{2 * (V_{OH}-V_{OL})\}$ $V_{IN}(V_{IN+}-V_{IN-})$ : differential input voltage $V_{OUT+}-V_{OUT-}$ : differential output voltage	
$V_{OUT}$ non-linearity ( $\pm 200$ mV) drift vs ambient temperature	$ dNL_{200}/dT_a $	The temperature coefficient of the non-linearity variations (from maximum to minimum value) in ambient temperature range.	
$V_{OUT}$ non-linearity ( $\pm 100$ mV)	$NL_{100}$	The ratio of the sum of the maximum deviations in the positive and negative directions (dev_max and dev_min) of the measured points from the approximate straight line of $V_{IN}-(V_{OUT+}-V_{OUT-})$ curve to the full-scale differential output voltage ( $\{2 * (V_{OH}-V_{OL})\}$ ). $NL_{200}$ is specified over the $V_{IN}$ range between -0.1 and +0.1 V. $V_{IN}(V_{IN+}-V_{IN-})$ : differential input voltage $V_{OUT+}-V_{OUT-}$ : differential output voltage	

Term	Symbol	Description	Characteristics Curve
High-level output voltage	$V_{OH}$	Maximum single-phase output voltage of $V_{OUT+}$ and $V_{OUT-}$ .	
Low-level output voltage	$V_{OL}$	Minimum single-phase output voltage of $V_{OUT+}$ and $V_{OUT-}$ .	
Input common-mode rejection ratio	$CMRR_{IN}$	The ratio of the gain from a common-mode input GCM to the differential input G  $CMRR_{IN}$ is specified over the $V_{IN}$ range between $-0.2$ and $+0.2$ V.  $CMRR_{IN} = 20\log(G/ GCM )$ [dB]	
Equivalent input resistance	$R_{IN}$	Equivalent input resistance over the $V_{IN}(V_{IN+}-V_{IN-})$ range between $-0.2$ and $+0.2$ V.	-
Input bias current	$I_{IN+}$	The input current when the differential input voltage $V_{IN}(V_{IN+}-V_{IN-})$ is 0 V	-
Input side supply current ( $V_{DD1}$ )	$I_{DD1}$	The supply current that flows through the input side when the differential input voltage $V_{IN}(V_{IN+}-V_{IN-})$ is 0 V	-
Output side supply current ( $V_{DD2}$ )	$I_{DD2}$	The supply current that flows through the output side when the differential input voltage $V_{IN}(V_{IN+}-V_{IN-})$ is 0 V	-
Output resistance ( $V_{OUT}$ )	$R_{OUT}$	Resistance of the output pin over the output current range of $\pm 5$ mA	-

**1.2 AC characteristics**

Term	Symbol	Description	Characteristics Curve
$V_{OUT}$ bandwidth (-3 dB)	$f_{-3dB}$	The frequency at which the gain drops by -3 dB on input-output frequency dependence against an input sine wave.	-
$V_{IN}$ to $V_{OUT}$ propagation delay time (10%-10%)	$t_{PD10}$	Propagation delay time from $V_{IN}$ to $V_{OUT}$ . Propagation delay times from 10% of input to 10% of output, from 50% of input to 50% of output, and from 90% of input to 90% of output are specified as $t_{PD10}$ , $t_{PD50}$ , and $t_{PD90}$ , respectively.	
$V_{IN}$ to $V_{OUT}$ propagation delay time (50%-50%)	$t_{PD50}$		
$V_{IN}$ to $V_{OUT}$ propagation delay time (90%-90%)	$t_{PD90}$		
$V_{OUT}$ rise time	$t_r$	Rise time of the differential output voltage $V_{OUT+} - V_{OUT-}$ .	
$V_{OUT}$ fall time	$t_f$	Fall time of the differential output voltage $V_{OUT+} - V_{OUT-}$ .	
Common-mode transient immunity	CMTI	The maximum tolerable rising or falling rate of input-to-output common-mode voltage at which the prescribed output voltage can be maintained.	

2. Electrical characteristics of digital-output isolation amplifiers

2.1 DC characteristics

Term	Symbol	Description	Characteristics Curve
Integral non-linearity	INL	<p>The maximum deviation of the <math>V_{IN}</math>-MDAT characteristics from the ideal line.</p> <p>INL is expressed in LSB or as a percent (%) of the input range, and specified over the <math>V_{IN}</math> range between -0.2 and +0.2 V.</p> <p>* Ideal line</p> <p>The line that assume output changes with 16bit resolution (65536 step) over the ideal input voltage range (<math>\pm 320</math> mV) determined by the internal reference voltage</p> <p><math>V_{IN}</math> (<math>V_{IN+}-V_{IN-}</math>): Differential input voltage MDAT: Digital code output</p>	<p>(This figure should be considered merely as a guide.)</p>
Differential non-linearity	DNL	<p>The maximum deviation of the actual step width of the <math>V_{IN}</math>-MDAT characteristics from the ideal step width (1 LSB)</p> <p>DNL is expressed in LSB units, and specified over the <math>V_{IN}</math> range between -0.2 and +0.2 V.</p> <p>* Ideal step width (1 LSB)</p> <p>Ideal input voltage range (<math>\pm 320</math> mV) and output steps (16-bit 65536 step) determine the ideal step width "LSB", 1LSB = 640 mV / 65536 = 9.7 <math>\mu</math>V=1LSB</p> <p><math>V_{IN}</math> (<math>V_{IN+}-V_{IN-}</math>): Differential input voltage MDAT: Digital code output</p>	<p>(This figure should be considered merely as a guide.)</p>
Input offset voltage	$V_{OS}$	<p>The converted offset voltage obtained by dividing the deviation from the ideal digital code value (32768) at <math>V_{IN}</math> (<math>V_{IN+}-V_{IN-}</math>) of 0V by the gain (<math>1+G_E</math>) with negative coefficient. (Intercept on the <math>V_{IN}</math> axis in the <math>V_{IN}</math>-MDAT curve)</p>	
Input offset voltage drift vs ambient temperature	$ dV_{OS}/dT_a $	<p>The temperature coefficient of the input offset voltage variations (from maximum to minimum value) in ambient temperature range.</p>	
Input offset voltage drift vs input side supply voltage	$ dV_{OS}/dV_{DD1} $	<p>The voltage dependency coefficient of the input offset voltage variations (from maximum to minimum value) in input side supply voltage range.</p>	

Term	Symbol	Description	Characteristics Curve
Internal reference voltage	$V_{REF}$	The differential input voltage that provides the minimum (0) or maximum (65536) output digital code value in the $V_{IN}$ -MDAT characteristics  $V_{IN}$ ( $V_{IN+}$ - $V_{IN-}$ ): Differential input voltage MDAT: Digital code output	
Gain error	$G_E$	The percentage (%) of the error of the slope of an approximate straight line from the ideal line (input-to-output gain: 1) in the $V_{IN}$ -MDAT characteristics.  $G_E$ is specified over the $V_{IN}$ range between -0.2 and +0.2 V.  $V_{IN}$ ( $V_{IN+}$ - $V_{IN-}$ ): Differential input voltage MDAT: Digital code output	
Input common-mode rejection ratio	$CMRR_{IN}$	The ratio of the gain from a common-mode input (GCM) to the differential input gain (1+ $G_E$ ).  $CMRR_{IN}$ is specified over the $V_{IN}$ range between -0.2 and +0.2 V.  $CMRR_{IN}=20\log\{(1+G_E)/ GCM \}$ (dB)	
Signal-to-noise ratio	SNR	The ratio of the level of a desired signal to the level of noise (except harmonics).  SNR is specified with a 1kHz, 0.4V <sub>p-p</sub> sine wave.	
Signal-to-(noise + distortion) ratio	SNDR	The ratio of the level of a desired signal to the level of noise (including harmonics).	
Effective number of bits	ENOB	Signal resolution (effective number of bits) calculated from the SNDR characteristics.  $ENOB = (SNDR - 1.76)/6.02$	
Total harmonic distortion	THD	The ratio of the harmonic components to the fundamental component.	
Input side supply current ( $V_{DD1}$ )	$I_{DD1}$	The supply current that flows through the input side when the differential input voltage $V_{IN} = (V_{IN+}-V_{IN-})$ is 0 V.	-
Output side supply current ( $V_{DD2}$ )	$I_{DD2}$	The supply current that flows through the output side when the differential input voltage $V_{IN}(V_{IN+}-V_{IN-})$ is 0 V.	-
Low-level output voltage	$V_{OL}$	Minimum voltage of the MDAT and MCLK outputs.	-
High-level output voltage	$V_{OH}$	Maximum voltage of the MDAT and MCLK outputs.	-
Equivalent input resistance	$R_{IN}$	Equivalent input resistance over the $V_{IN}(V_{IN+}-V_{IN-})$ range between -0.2 and +0.2 V.	-

**2.2 AC characteristics**

Term	Symbol	Description	Characteristics Curve
Output clock frequency	$f_{CLK}$	The frequency of the clock from the MCLK pin (with a period equal to that of the bitstream data of MDAT pin).	
Access time after MCLK rising edge	$t_a$	The period of time required for MDAT to finish a High-to-Low or Low-to-High transition from the rising edge of MCLK.	
Hold time after MCLK rising edge	$t_h$	The period of time required for MDAT to begin a High-to-Low or Low-to-High transition from the rising edge of MCLK.	
Common-mode transient immunity	CMTI	The maximum tolerable rising or falling rate of input-to-output common-mode voltage at which the prescribed output voltage can be maintained.	-

**Revision History**

Revision	Date	Page	Description
Rev. 1.0	2019/2/18	-	First edition



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