Analog Engineer's Circuit

LVDS data and clock recovery circuit with high-speed comparators

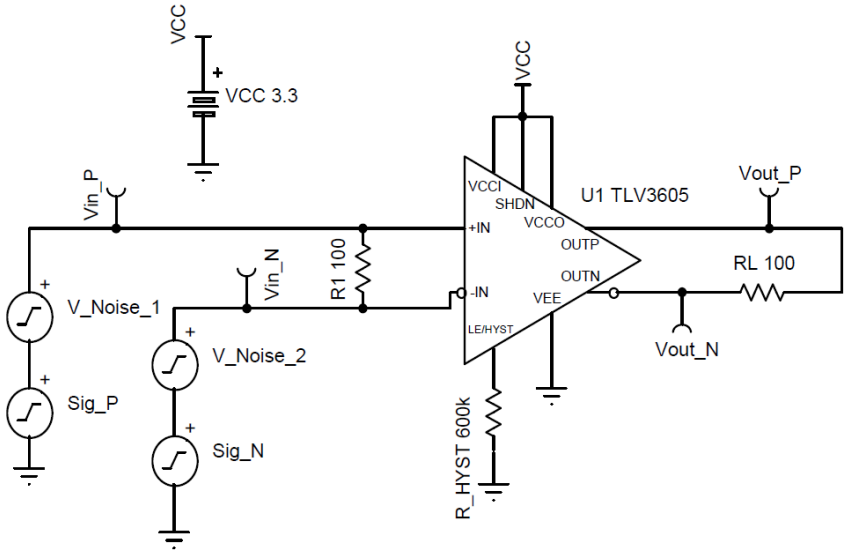
Amplifiers

Design Goals

Supply		Attenuated Input Signal		
V_{cc}	V_{ee}	V_i	V_{cm}	f
3.3V	0V	$50mV_{p-p}$	1.2V	1GHz

Design Description

The LVDS signal restoration circuit is used in digital systems to retrieve distorted clock or data waveforms. These clock and data signals can be attenuated and distorted on long traces due to stray capacitance, stray inductance, or reflections on transmission lines. The comparator is used to sense the attenuated and distorted input signal and convert it into a full scale LVDS output signal. This circuit can also be used to convert from single-ended signals to LVDS signaling. In that case, a dynamic reference voltage is connected to the inverting terminal of the comparator which is extracting the common-mode voltage from the input signal.



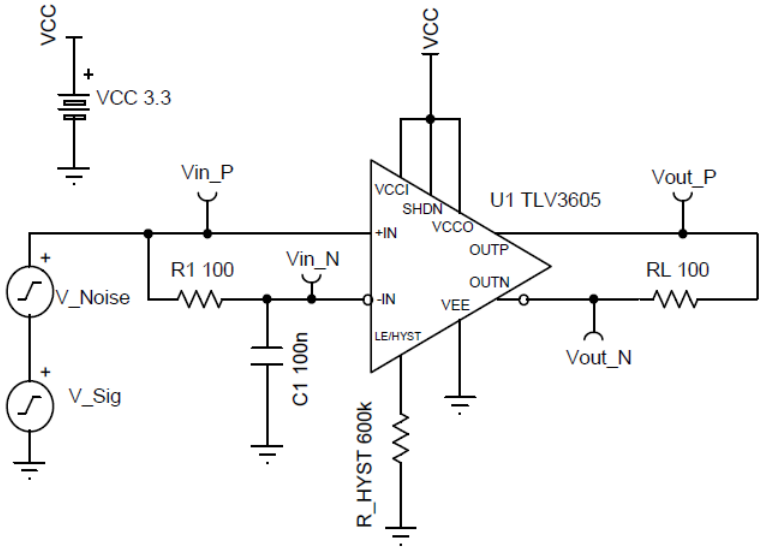
Design Notes

1. Select a comparator with low input offset voltage and fast propagation delay.
2. A comparator with a toggle frequency larger than the input signal frequency should be used to properly process the incoming digital signal. A margin of 30% is sufficient to allow for process and temperature variations if a minimum value is not warranted in the data sheet.
3. The signal should be symmetric around the waveform midpoint for the dynamic reference to accurately determine the common mode voltage of the input signal. For signals with duty cycles outside of 30–70%, the dynamic reference must be replaced with an external reference source.

Design Steps (LVDS Input)

1. Connect the positive and negative portions of the LVDS input to the non-inverting and inverting terminals, respectively, of the comparator.
2. Ensure that the LVDS signal is properly terminated with a 100-Ω resistor, R_1, connected between both inputs.
3. Connect VCC to the TLV3605 $\overline{\text{SHDN}}$ pin to disable the shutdown feature of the device.
4. Terminate the output signals using a 100-Ω resistor, R_L, connected between both nodes.
5. If the input signals are noisy in addition to being attenuated, TLV3605 is able to handle the noise though implementation of its adjustable hysteresis feature. This pin can be driven with a voltage source or be attached to a resistor to VEE and can cause the comparator to have a hysteresis up to 65mV, as well as latching the output depending on the voltage seen at the pin. See the *TLV3604, TLV3605 800-ps High-Speed RRI Comparator with LVDS Outputs* data sheet for more information. For this circuit, a hysteresis of 10mV is implemented to counter the noisy input signals by connecting a 600-kΩ resistor to VEE.

Design Steps (Single-Ended Input)



1. Set the non-inverting input of the comparator to the input data signal.
2. Create a dynamic reference from a low-pass network using a capacitor, C_1, and resistor, R_1. Connect the input of the network to the non-inverting input and the output to the inverting input.
3. Size the values of the dynamic reference so that its cutoff frequency is significantly below the operating frequency of the input signal while ensuring the time constant of the network is small enough for maximum responsivity. Let C_1 = 0.1µF and designing for a time constant τ of 10µs, calculate the needed resistor value:

$$\tau = R_1 C_1$$

$$10\mu s = R_1(100nF) \Rightarrow R_1 = 100\Omega$$

Using the solved-for resistor value, ensure the cutoff frequency is still significantly below the input signal frequency.

$$f_{cutoff} = \frac{1}{2\pi R_1 C_1} = \frac{1}{2\pi(100\Omega)(100nF)} = 15.915khz \ll 1GHz$$

The time constant τ has an inverse relationship with f_{cutoff}. The quicker τ is, the more reactive the dynamic reference output node is to the input while pushing the cutoff frequency higher. However, if the cutoff frequency of the dynamic reference approaches the operating frequency of the input signal, the output of the network is unable to properly filter out the high-frequency component of the input signal, thereby failing to generate a stable DC reference voltage to compare the input signal against.

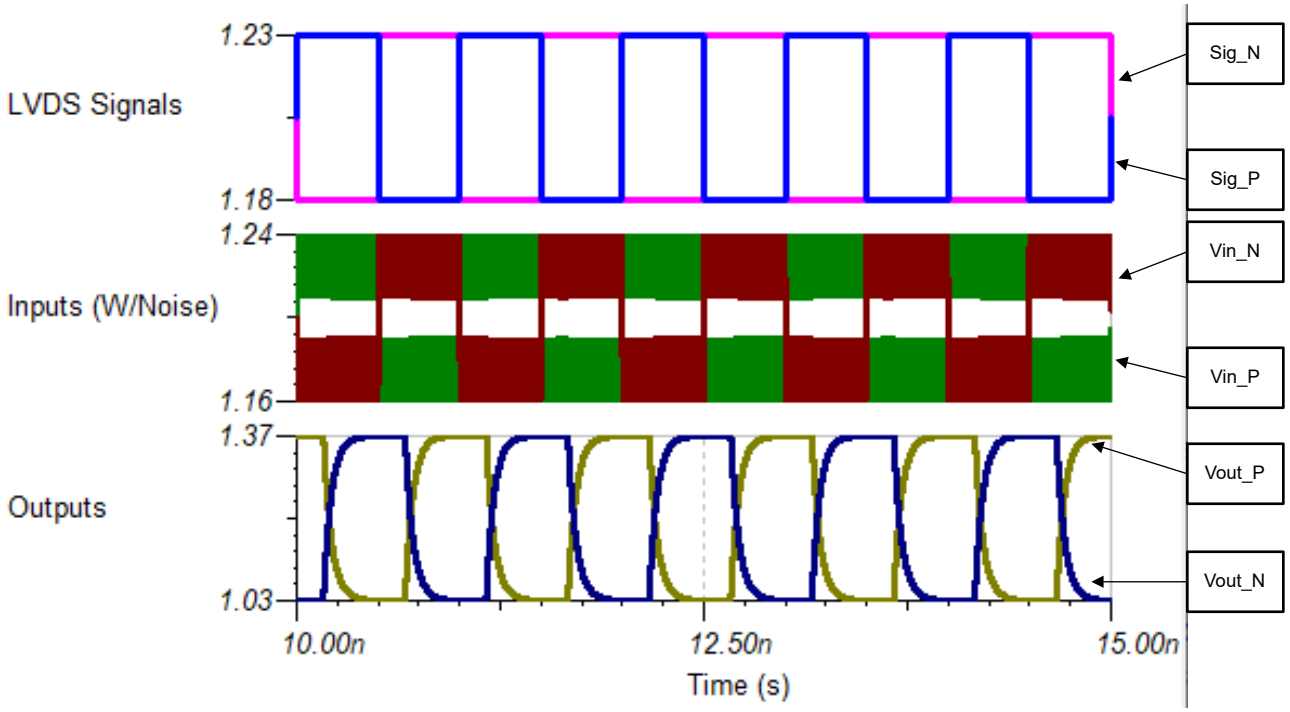
A ramification to consider when balancing the accurate filtering of the signal versus τ is start-up time. As the system starts in an uncharged state, once the system is active, there is a time period (around 5τ) until the voltage level at the inverting input is at an accurate level.

4. Connect VCC to the TLV3605 $\overline{\text{SHDN}}$ pin to disable the shutdown feature of the device.
5. Terminate the output signals using a 100-Ω resistor R_L connected between both nodes.
6. If the input signal is noisy in addition to being attenuated, the TLV3605 is able to handle the noise though implementation of its adjustable hysteresis feature. This pin can be driven with a voltage source or be attached to a resistor to VEE and can cause the comparator to have a hysteresis up to 65mV, as well as latching the output depending on the voltage seen at the pin. See the *TLV3604, TLV3605 800-ps High-Speed RRI Comparator with LVDS Outputs* data sheet for more information. For this circuit, a hysteresis of 10mV is implemented to counter the noisy input signals by connecting a 600-kΩ resistor to VEE.

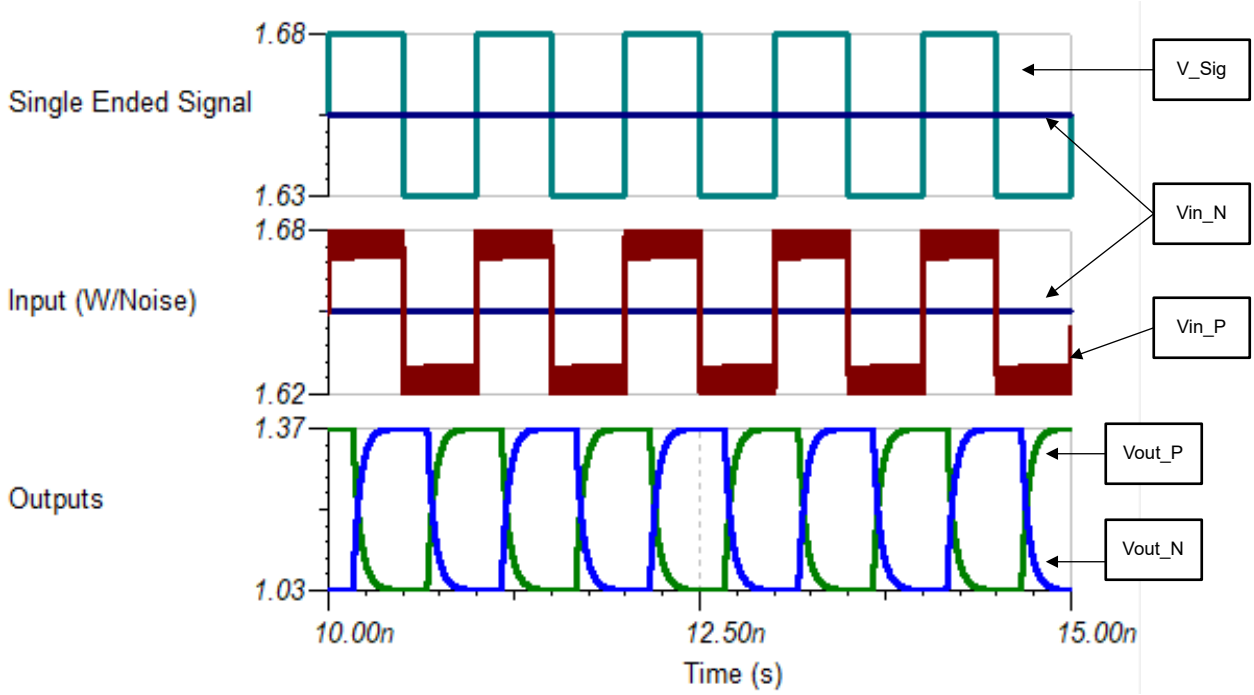
Design Simulations

Transient Simulation Results

LVDS Input



Single-Ended Input



Design References

See *Analog Engineer's Circuit Cookbooks* for TI's comprehensive circuit library.

See circuit spice simulation file, SNOM771 (LVDS) and SNOM710 (Single-Ended).

For more information on many comparator topics including hysteresis, propagation delay and input common mode range please see, TI Precision Labs.

Design Featured Comparator

TLV3605	
V_{ss}	2.4V to 5.5V
V_{inCM}	Rail-to-rail
t_{pd}	800ps
V_{os}	0.5mV
V_{HYS}	Adjustable (0–65mV)
I_q	12.7mA
Output Type	LVDS
f_{toggle}	1.5GHz
#Channels	1
www.ti.com/product/TLV3605	

Design Alternate Comparator

	TLV3604	LMH7220
V_{ss}	2.4V to 5.5V	2.7V to 12V
V_{inCM}	Rail-to-rail	Rail-to-rail
t_{pd}	800ps	2.9ns
V_{os}	0.5mV	9.5mV
V_{HYS}	N/A	N/A
I_q	12.1mA	6.8mA
Output Type	LVDS	LVDS
f_{toggle}	1.5GHz	440MHz
#Channels	1	1
	www.ti.com/product/tlv3604	www.ti.com/product/lmh7220

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