Analog Engineer's Circuit

Zero Crossing Detection Using Comparator Circuit

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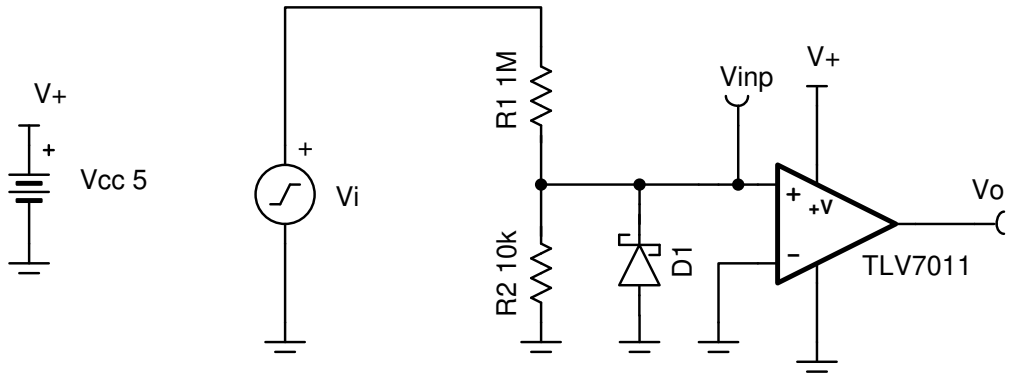
Design Goals

Supply			Input Signal		MAX AC Mains Leakage Current
V_{cc}	V_{ee}	Type	V_i	f	I_{ac}
5V	0V	Single	240V AC RMS	50Hz	<500µA

Design Description

The zero crossing detector circuit changes the comparator output state when the AC input crosses the zero reference voltage. This is done by setting the comparator inverting input to the zero reference voltage and applying the attenuated input to the noninverting input. The voltage divider R_1 and R_2 attenuates the input AC signal. The diode D_1 is used to insure the noninverting input never goes below the negative input common mode limit of the comparator. Zero crossing detection is often used in power control circuits.



Design Notes

1. Use some hysteresis to prevent unwanted transitions due to the slow speed of the input signal.
2. Select a comparator with a large input common mode range
3. The phase inversion protection feature of the TLV7011 can prevent phase reversal in situations where the input goes outside of the input common mode limits
4. Use a diode to protect the comparator when the input goes below the negative input common mode limit.

Design Steps

1. Calculate the peak value of the input signal.

$$V_p = V_{RMS} \times \sqrt{2} = 340V$$

2. Select the resistor divider to attenuate the input 340 V signal down to 3.4V to be within the positive common range of the comparator.

$$340V \times G = 3.4V$$

$$G = 0.01\frac{V}{V}$$

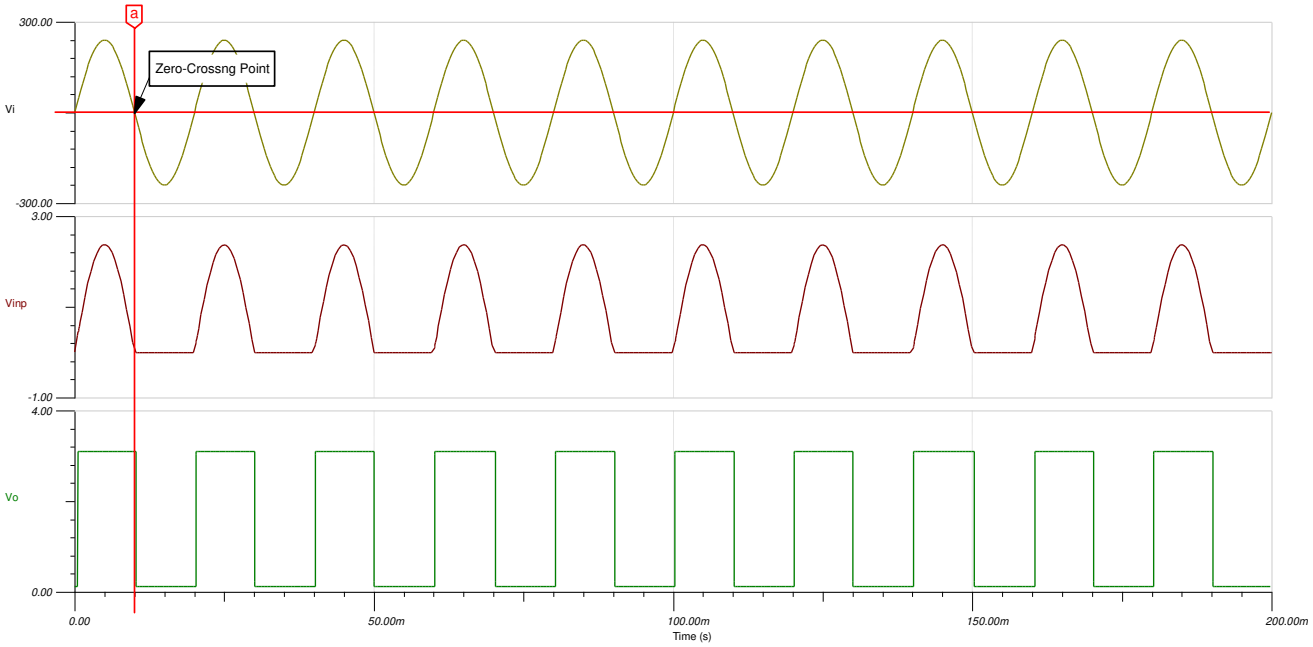
$$\left(\frac{R_2}{R_1+R_2}\right) = 0.01$$

3. Select R_1 as 1MΩ and R_2 as 10kΩ (the closest 1% value).
4. Select the diode, D_1, to limit the negative voltage at the noninverting input. Use a zener diode with a voltage rating of 0.3V.
5. Calculate the AC mains leakage current to check if it meets the leakage current design goal of less than 500µA.

$$I_{ac} = \frac{V_p}{R_1} = 340\mu A$$

Design Simulations

Transient Simulation Results



Design References

Texas Instruments, SBOMAP5 simulation, circuit file

Design Featured Comparator

TLV7011	
V_{ss}	1.6V to 5.5V
V_{inCM}	Rail-to-rail
t_{pd}	260ns
V_{os}	0.5mV
V_{HYS}	4mV
I_q	5µA
Output Type	Push-Pull
#Channels	1
TLV7011	

Design Alternate Comparator

TLV3201	
V_{ss}	2.7V to 5.5V
V_{inCM}	Rail-to-rail
t_{pd}	40ns
V_{os}	1V
V_{HYS}	1.2mV
I_q	40µA
Output Type	Push-Pull
#Channels	1
TLV3201	

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