

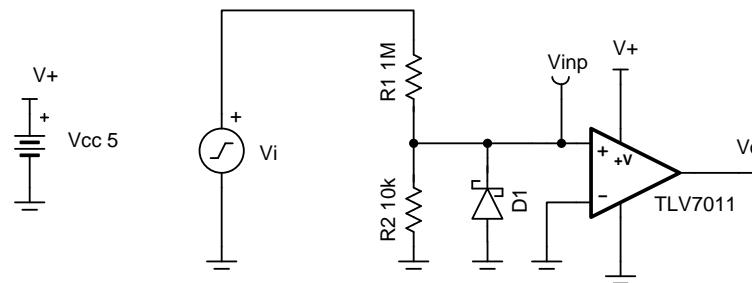
## Zero crossing detection using comparator circuit

### 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	<500 $\mu$ A

### Design Description

The zero crossing detector circuit changes the comparator's 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. Some hysteresis should be used 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. A diode should be used 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 340V signal down to 3.4V in order to be within the positive common range of the comparator.

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

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

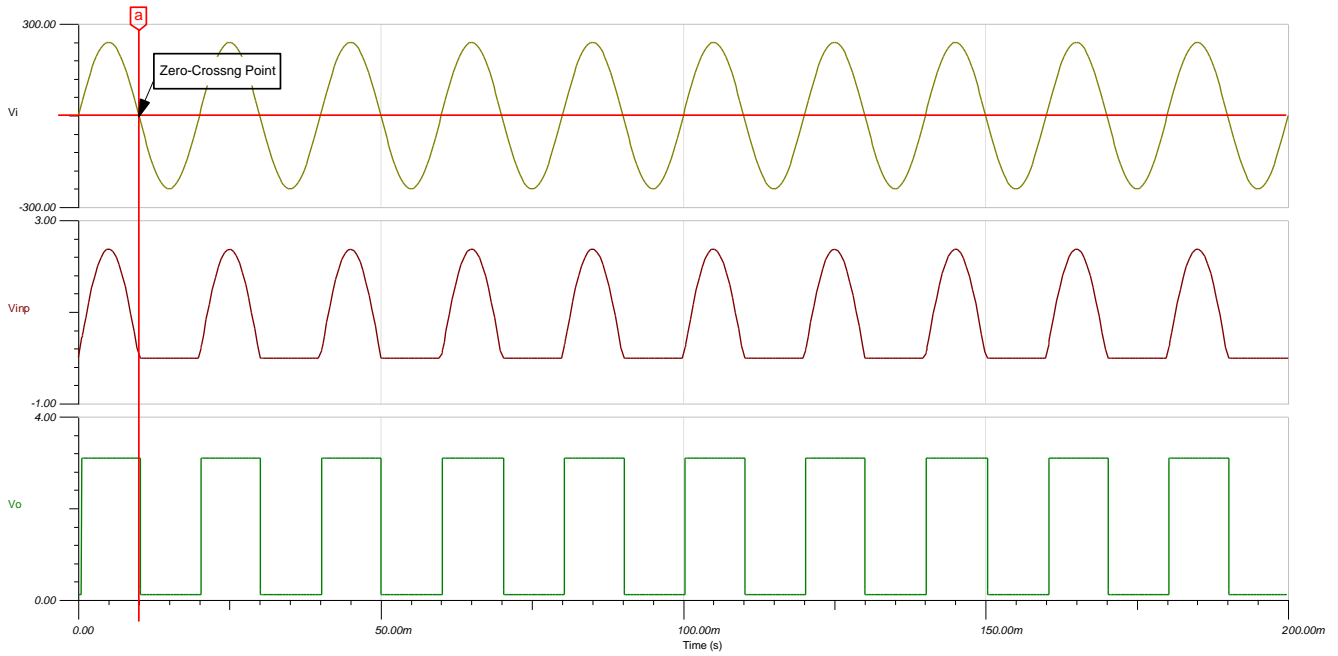
$$\left( \frac{R_2}{R_1 + R_2} \right) = 0.01$$

3. Select  $R_1$  as 1M $\Omega$  and  $R_2$  as 10k $\Omega$  (the closest 1% value).
4. Select the diode,  $D_1$ , in order to limit the negative voltage at the noninverting input. A zener diode with a voltage rating of 0.3V can be used.
5. Calculate the AC mains leakage current to check if it meets the leakage current design goal of less than 500 $\mu$ A.

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

## Design Simulations

### Transient Simulation Results



## Design References

See [Analog Engineer's Circuit Cookbooks](#) for TI's comprehensive circuit library.

See circuit spice simulation file, [SBOMAP5](#).

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

## Design Featured Comparator

TLV7011	
$V_{SS}$	1.6 to 5.5V
$V_{inCM}$	Rail-to-rail
$t_{pd}$	260ns
$V_{os}$	0.5mV
$V_{HYS}$	4mV
$I_q$	5 $\mu$ A
Output Type	Push-Pull
#Channels	1
<a href="http://www.ti.com/product/tlv7011">www.ti.com/product/tlv7011</a>	

## Design Alternate Comparator

TLV3201	
$V_{SS}$	2.7 to 5.5V
$V_{inCM}$	Rail-to-rail
$t_{pd}$	40ns
$V_{os}$	1V
$V_{HYS}$	1.2mV
$I_q$	40 $\mu$ A
Output Type	Push-Pull
#Channels	1
<a href="http://www.ti.com/product/tlv3201">www.ti.com/product/tlv3201</a>	

## IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to TI's Terms of Sale ([www.ti.com/legal/termsofsale.html](http://www.ti.com/legal/termsofsale.html)) or other applicable terms available either on [ti.com](http://ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2019, Texas Instruments Incorporated