APPLICATION NOTE AN-441

Line Synchronous Switching / Zero Crossing Detection

Keywords: **AC, Line, Synchronous, Zero-Cross, Isolated, Universal**

Specifications Reference: **None**

Scope: **BPSX, BPWX and BPH Modules**

Reference Application Notes: **AN-125**

Introduction:

Many applications can benefit by operating in synchronism with the AC power line. Examples range from timing circuits and clocks to electric meters and relay drivers. A crude "zero crossing detector" can be created for this purpose using an optocoupler with a dropping resistor. Although functional, approaches like this are limited when operation from a wide range of AC mains is desired. Additionally, the dropping resistors can contribute non-trivial heating in some applications. Though possible to eliminate these negatives by increasing the complexity of the circuit, Bias Power technology offers a simpler approach.

Applications:

1. Designers can make significant improvements to enhance product reliability of mains-powered electromechanical (and some electronic devices) by operating in synchronism with the AC line. Inrush current peaks, contact wear, bearing wear and coupling torques are all minimized by zero-cross switching. Device candidates include motors, relays, solenoids, contactors, electromagnets, transformers, fluorescent ballasts, and many AC/DC power supplies. Whether switched directly or through pilot devices, good design practice suggests doing so at the zero-crossing of the AC line.
2. Electronic timing circuits can benefit from the long-term frequency stability of the AC power line. Although the accuracy of autonomous clock circuits is very high over short periods of time, maintaining long-term accuracy can be very expensive. By utilizing zero-cross detection and phase-locked-loop technology, long-term accuracy can be achieved at comparatively little cost. Time of day clocks are an excellent example.
3. The development of modern applications, while keeping spikes and EMI at a minimum, can be especially difficult when switching AC mains in and out. Noise produced during switching is dependent on the amplitude of the AC sinus at the actual switching point. To reduce this noise as much as possible, the switching would ideally be done at zero-crossing.
4. Zero-cross detection can also be used for other purposes, such as frequency calculation, relative phase measuring, power-fail detection and time interval measurement.

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The following zero-crossing circuit is designed for use with the Bias products identified in Scope

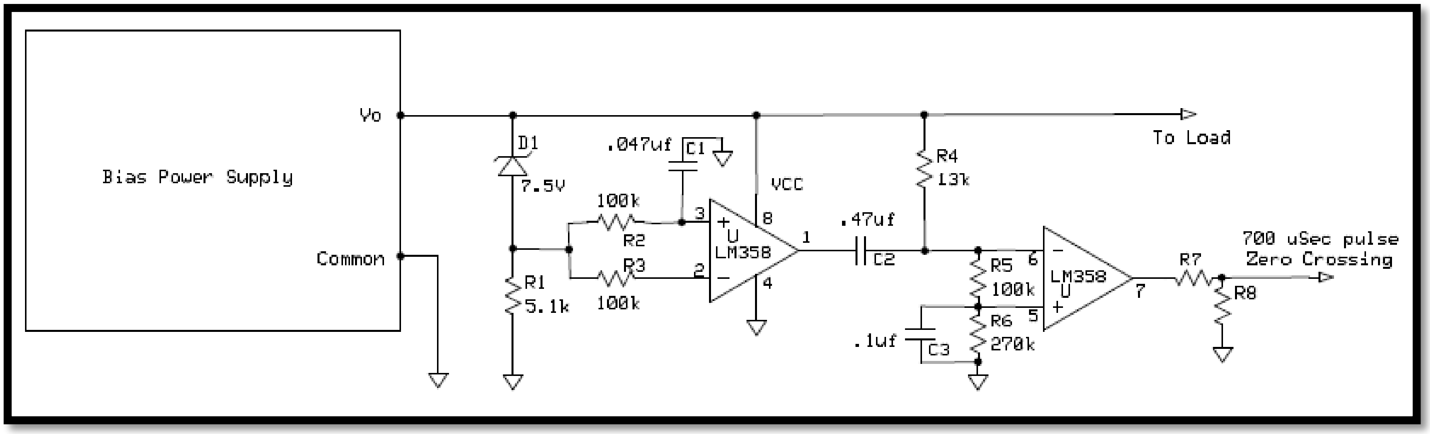

Figure 1

Notes to Figure 1:

1. As it operates on the DC side of the Bias power supply, the circuit is unaffected by changes in mains voltage. There is no need to change circuit values to accommodate product designs for the range of line voltages to be encountered.
2. Isolated from AC mains at the same rating as the power supply (3KV AC).
3. Unipolar pulse train easily integrates with an enable gate or microprocessor interrupt.
4. The output of the circuit is a positive, 700 µSec pulse. To scale this output to different values substitute values for R7 and R8 from Table 1.
5. The leading edge of the output pulse leads the AC line zero-cross by 400 µSec, +/- 200 µSec. See Figure 2.

Vo	Pulse voltage	R7, 1%	R8, 1%
8	3.3 volts	100K	71.5K
8	5.0 volts	100K	169K
12	3.3 volts	100K	38.3K
12	5.0 volts	100K	71.5K
14	3.3 volts	100K	30.9K
14	5.0 volts	100K	56.2K
24	3.3 volts	150K	24.3K
24	5.0 volts	150K	40.2K

Table 1

Sample output indicating relationship to AC mains:

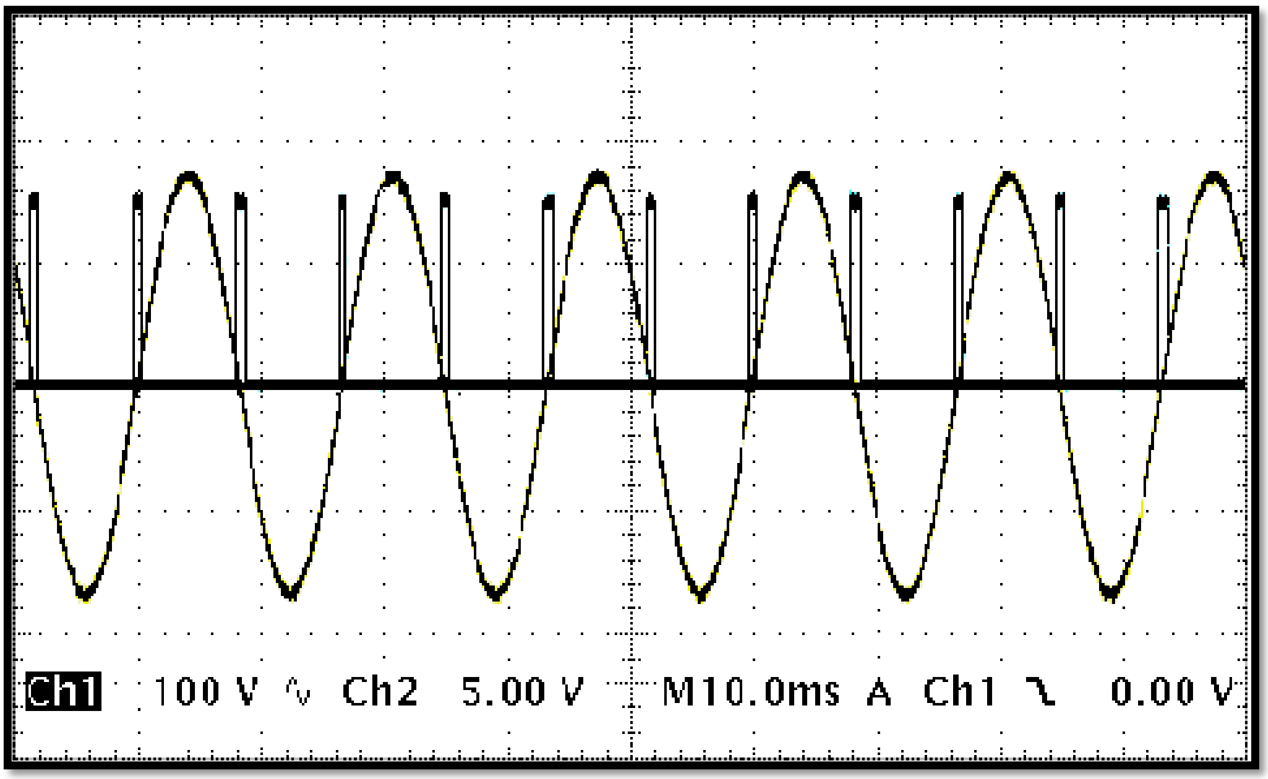

Figure 2

Restrictions:

1. This zero-cross detector approach is harmonized with Bias Power power supplies identified in Scope and the unique characteristics of the Bias Power Vo output, no applicability or suitability with other power supplies is expressed or implied.
2. This circuit operates only on the Vo output of the Bias supplies.
3. Results not guaranteed, testing has confirmed this circuit, your results may differ, testing for conformance still required. Variations in test methods, layout, adjacent components and devices may alter results.
4. The zero crossing signal is derived directly from the AC input without phase shifting. However, switching latency in electromechanical devices must be accounted for to achieve optimal operation relative to the zero crossing point.