Application Report
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AMC1100: Replacement of Input Main Sensing Transformer in Inverters with Isolated Amplifier

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ABSTRACT

This application note describes isolation amplifier design principles that can be used in Input AC main voltage sensing in Inverters. It describes the circuit operation along with the details of some examples. It is intended to give designers an alternative to bulky transformers for many industrial applications apart from Inverters.

Galvanic isolation is required for many circuits found in Telecommunication, Industrial, Medical and Instrumentation systems. This has been traditionally accomplished by means of transformers and optocouplers with transformers being used to couple AC signals and optocouplers used primarily for DC signal coupling. Operator safety and signal quality are also ensured with isolated interconnection.

Introduction

In the current design of Commercial 600 VA - 5 KVA inverters, the AC mains voltage is sensed by stepping down through a bulky 50 Hz transformer by the microcontroller which is powered up by battery through linear regulators. To ensure the operator safety (personal handling battery etc) and signal integrity, galvanic isolation is needed in the design.

Input A/C voltage Sensing
Through transformer

Figure 1.

The input AC Voltage Sensing is required in Inverters for changing to inverter mode through relay operation when A/C mains fall below the designated voltage level. Further comparators are also used in addition with transformer for location of zero crossing point of sinusoidal A/C signal.

a) Inverter Block Diagram

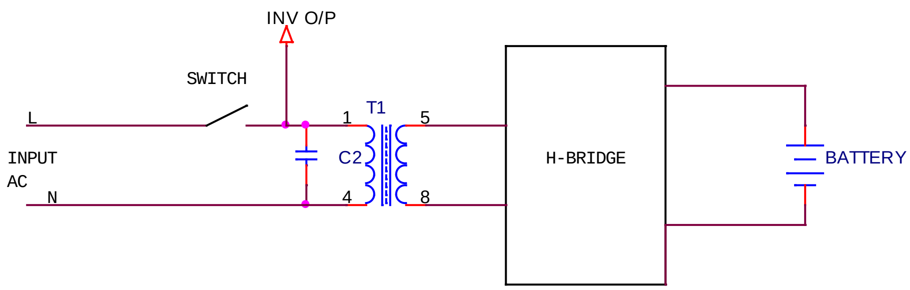


Figure 2.

The diagram in Figure 2 shows the operation of Inverter. Input AC voltage is fed to the transformer through a switch (relay). When input AC is present and is within valid range, the switch is closed and the input AC directly goes to the output load (INV O/P). The same AC fed to transformer, is used to drive the H-bridge consisting of mosfets or IGBTs to charge the battery. If the AC fails or is out of valid range (AC Voltage Sense is required), the switch opens. H-bridge circuit converts battery DC voltage into AC using high frequency PWM (5 kHz to15 KHz) thus feeding the same transformer which is being used for charging in the first case. The output of transformer contains a capacitor which filters it to make 50 Hz AC.

b) Current Circuit Design for Relay operation (Switching to Inverter or Mains mode by Sensing Input AC)

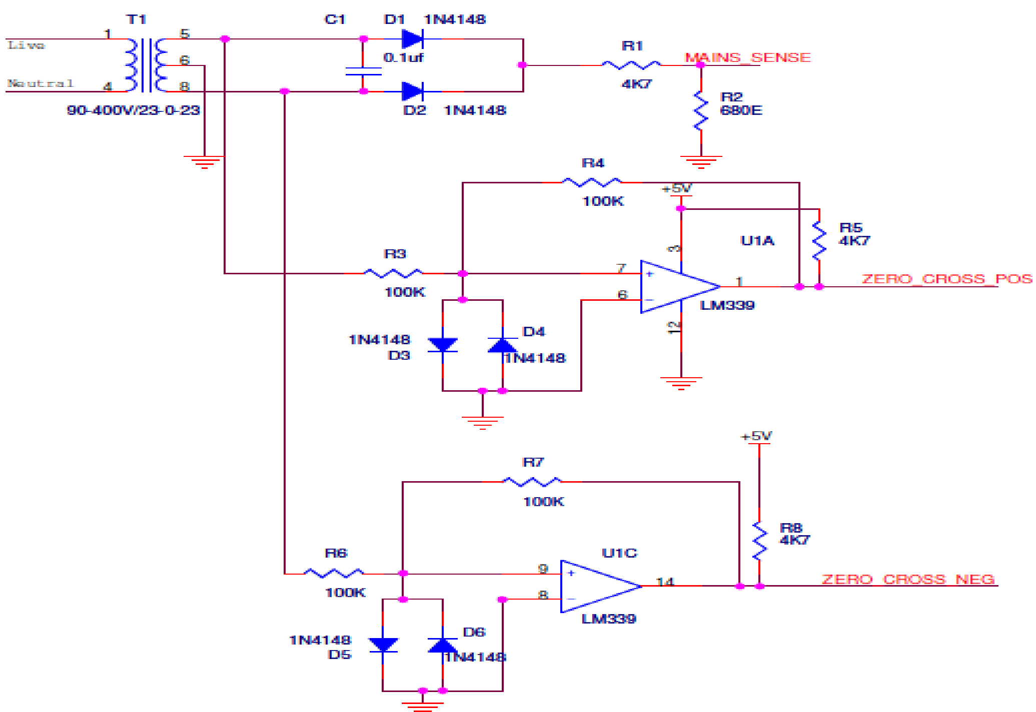


Figure 3.

As seen in Figure 3, a traditional 50 Hz transformer is used to generate a smaller replica of input AC voltage and then rectified further. Main_Sense signal is fed to the ADC of controller which controls the relay operation (Switch to inverter or mains mode). Also, comparators are used to locate the zero crossing of input AC signal and are given to the controller for generating PWM signals to be given to MOSFETS for controlling the charging.

Presenting an Innovative Input AC Voltage Sensing In Inverters

A precision isolation amplifier such as TI's AMC1100 with an output separated from the input circuitry by a silicon dioxide (SiO2) barrier is highly resistant to magnetic interference. This barrier has been certified to provide galvanic isolation of up to 4000 VPEAK according to UL1577 and IEC60747-5-2. Used in conjunction with isolated power supplies, this device can prevent noise currents on a high common-mode voltage line from entering the local ground and interfering with or damaging sensitive circuitry.

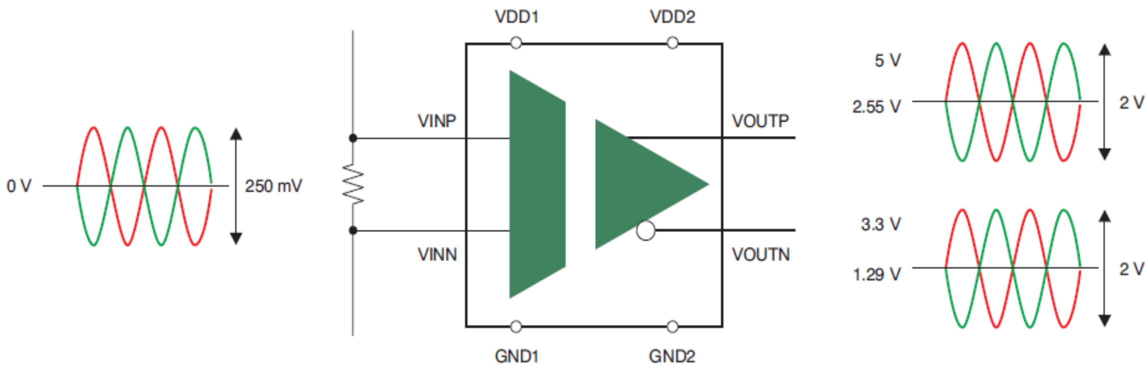


Figure 4.

The linearity and the noise performance of the device are ensured only when the differential analog input voltage remains within ±250 mV.

a) Application Schematic

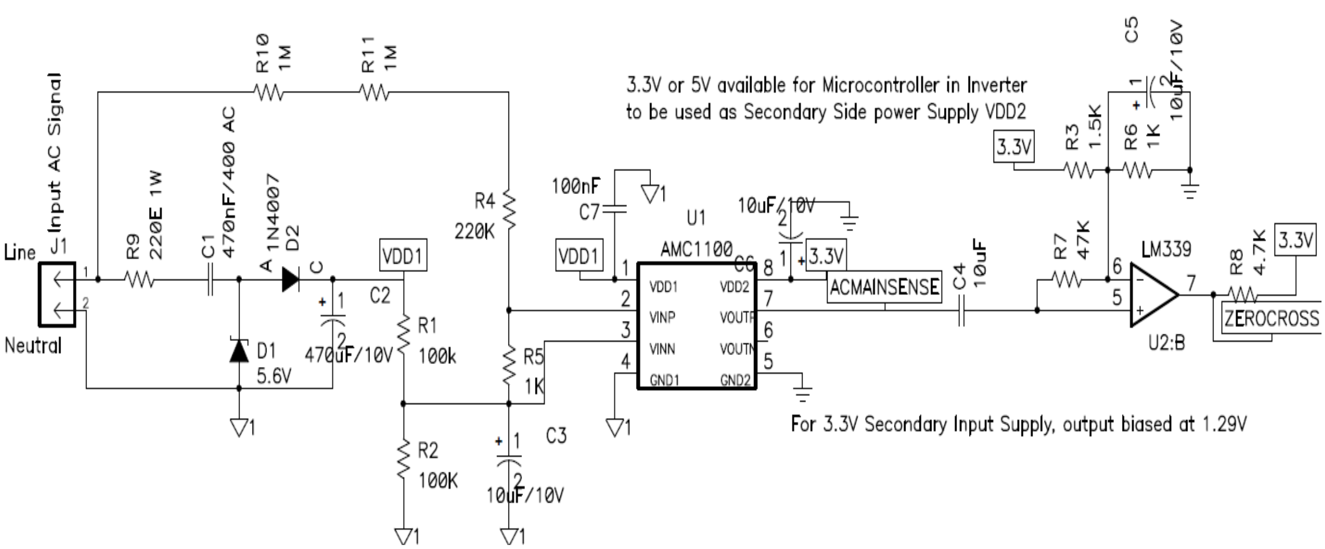


Figure 5.

b) Easy Design Guidelines:

1. From the AC mains input, a cap drop supply (C1, D1, D2, and C2) of 5 V is made with the help of 5.6 V Zener. For tighter regulation LDO can also be added.
2. Range of AC voltage to be sensed is determined. For inverters, it is generally between 90 VAC to 300 VAC.
3. Choose resistor divider at positive pin such that at the maximum AC input, the voltage at the VINP is less than +/- 250 mV. At 300 VAC, the peak value is at 425 V and hence resistor divider (R4 and R5) gives approximate peak of 190 mV at VINP, which is under 250 mV range
4. Based on the input pins (VINN and VINP) at VDD1/2 Volts ie in this case at 2.5 V and this is achieved through R1 and R2.
5. The analog output has a nominal gain of 8 through the AMC1100 isolation amplifier. With an input voltage of ±250 mV, the nominal output is therefore 2 V. The output voltage is centered on 1.29 V for 3.3 V Secondary Supply and provides a convenient analog input range to the embedded analog-to-digital converters (ADCs) the microcontroller.

c) Layout Guidelines

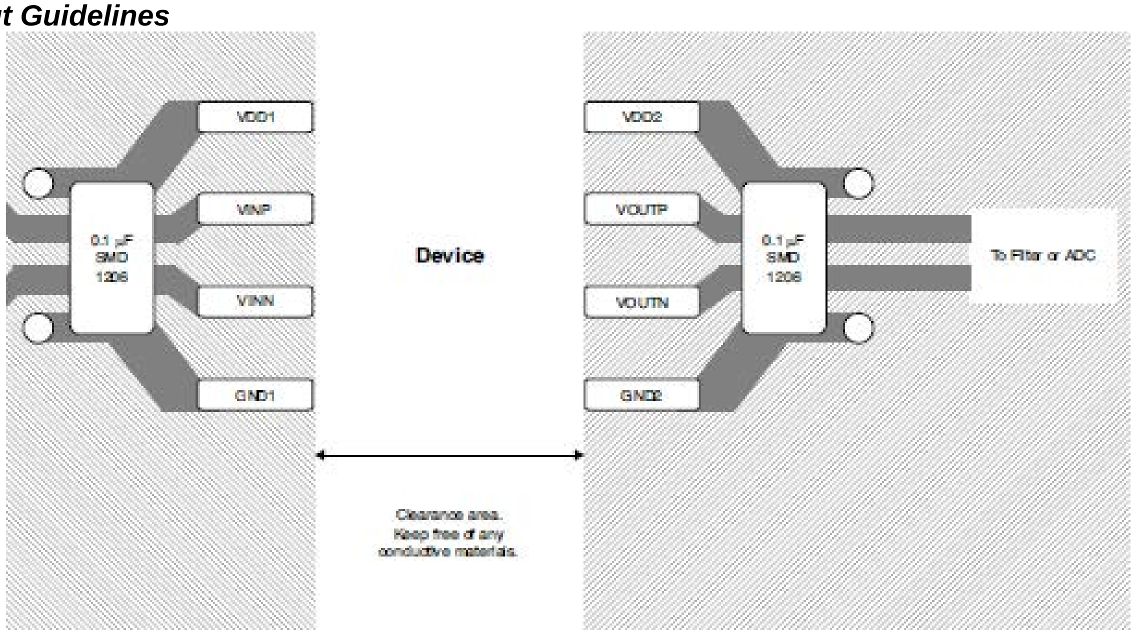


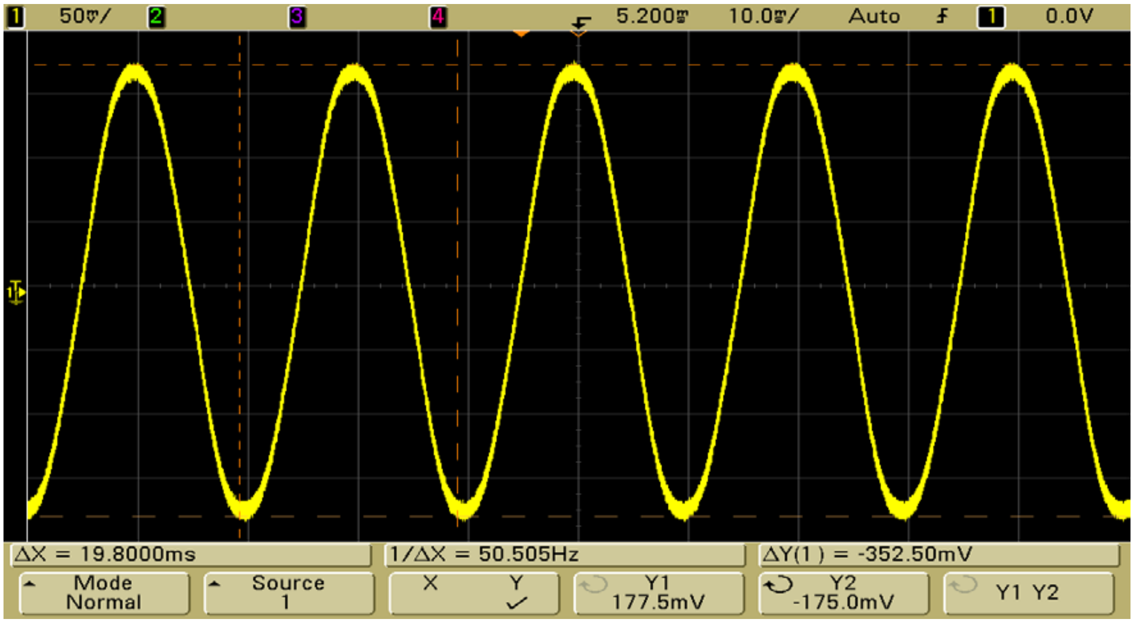
Figure 6.

1. To maintain the isolation barrier and the high common mode transient immunity of the device, the distance between the high-side ground (GND1) and the low-side ground (GND2) should be kept at maximum; that is, the entire area underneath the device should be kept free of any conducting materials.
2. It is recommended placing the bypass and filtering capacitors as close as possible to the AMC1100 to ensure best performance.

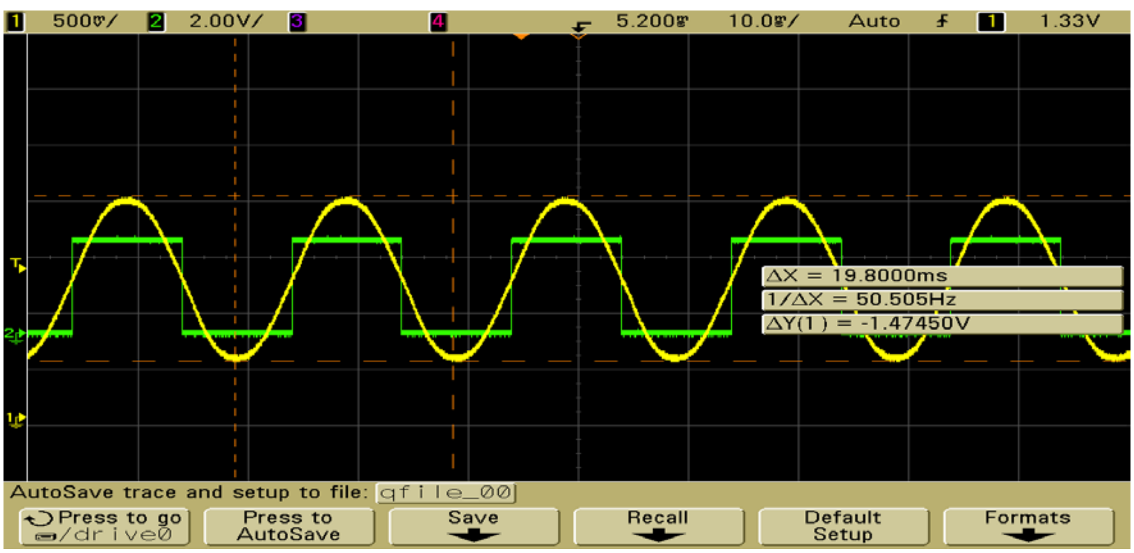
Test Results

a) At 270 VAC Input

1. VINP-VINN

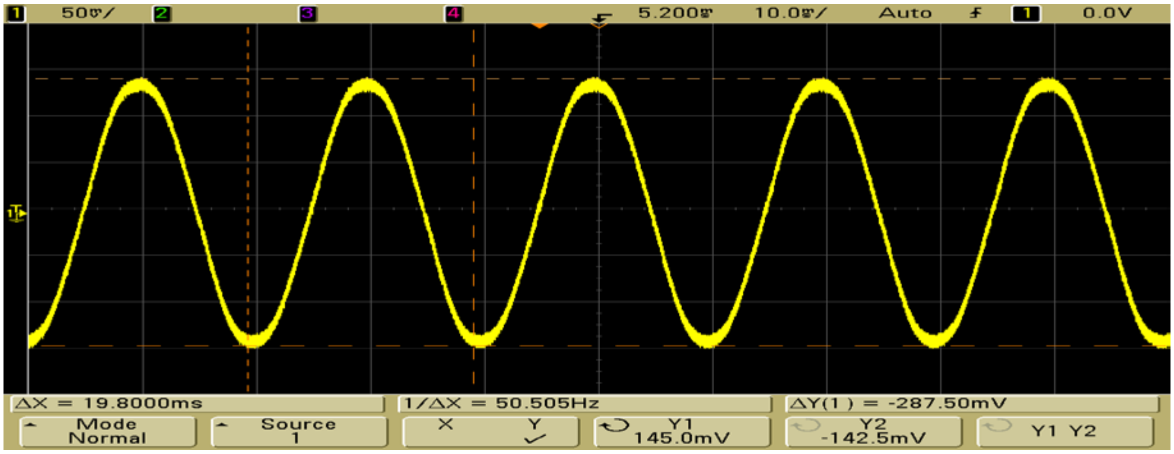


2. VOUTP and Zero Crossing

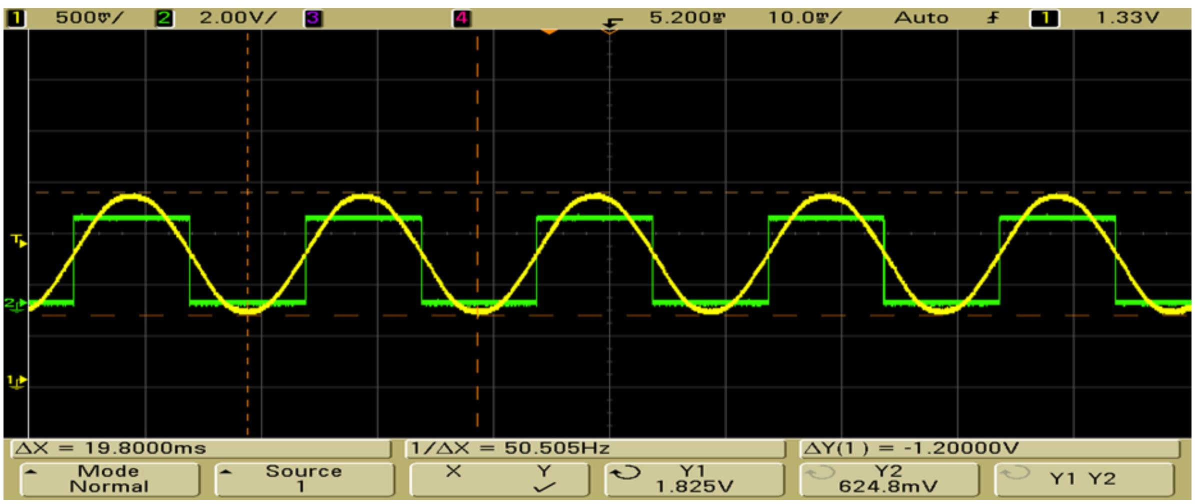


b) At 220VAC Input

1. VINP-VINN

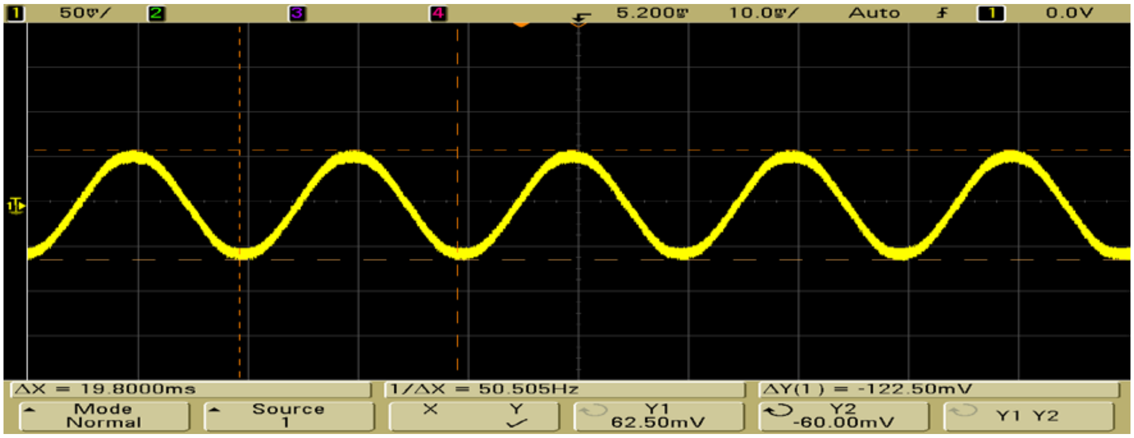


2. VOUTP and Zero Crossing

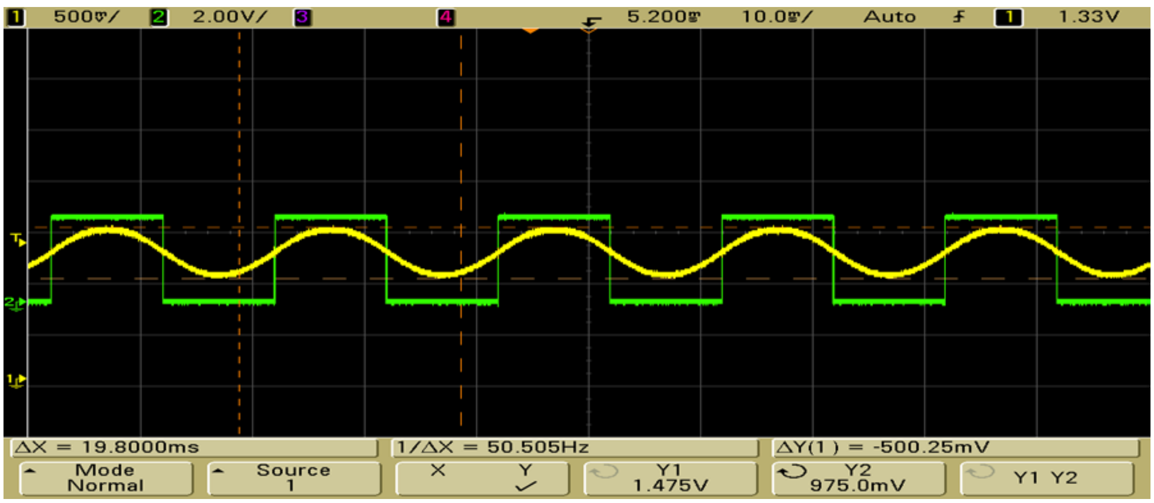


C) At 90 VAC Input

1. VINP-VINN

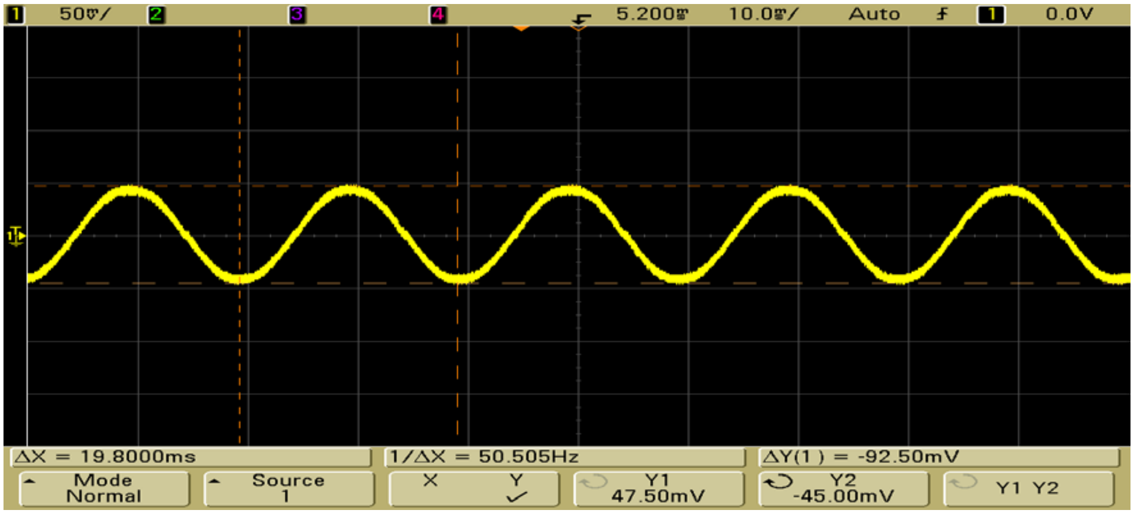


2. VOUTP and Zero Crossing

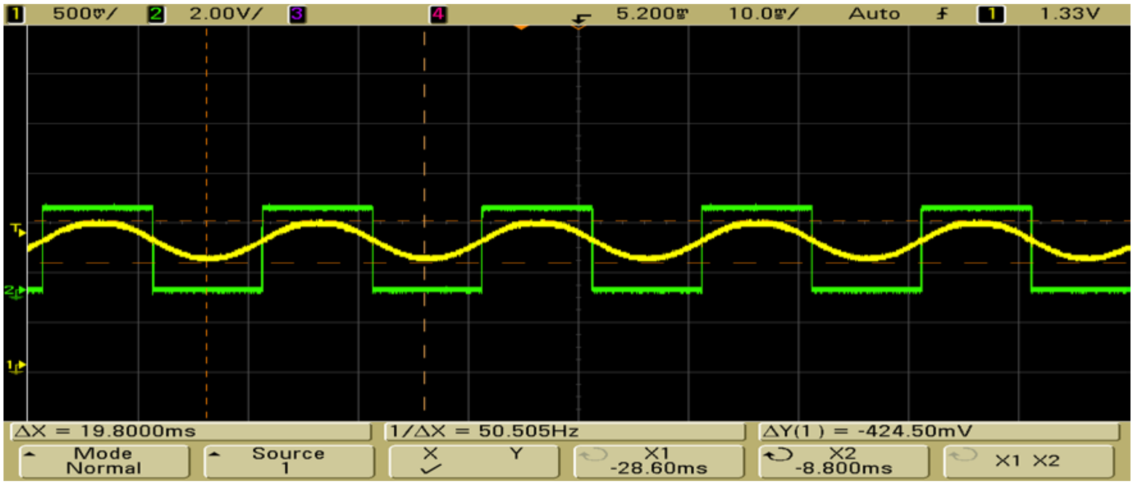


D) At 70VAC Input

1. VINP-VINN



2. VOUTP and Zero Crossing



Future Development – Cap Drop Replacement with Isolated Fly- Buck based Primary side Supply

The Cap Drop power supply will die down at low AC voltages (It does not matter in an inverter application as voltages of interest is in the range of 100 VAC-265 VAC) and hence isolated 5 V from the 12 V battery is required to power up the primary side. Generally 5 V or 3.3 V is available in inverters which is used to power up microcontroller, comparator etc. A simple topology is needed which takes 5 V input and generates 5 V isolated output.

The Isolated **Fly-Buck™ Topology** with the Primary side feedback can be used to provide regulated output voltage.

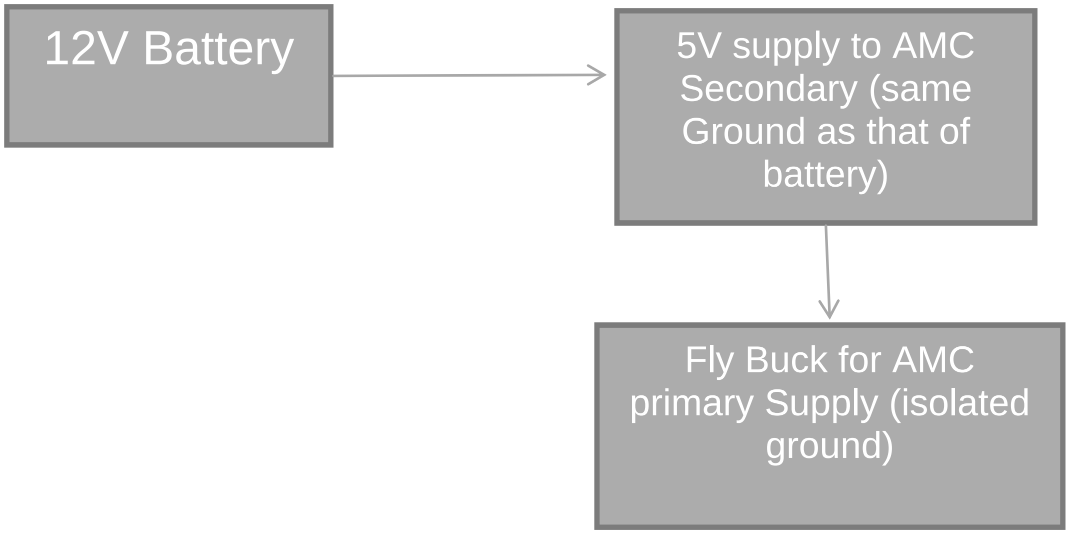


Figure 7.

TI's TPS55010 is a transformer driver that can be used in this application, designed to provide isolated power for isolated interfaces, from 3.3 V or 5 V input supply.

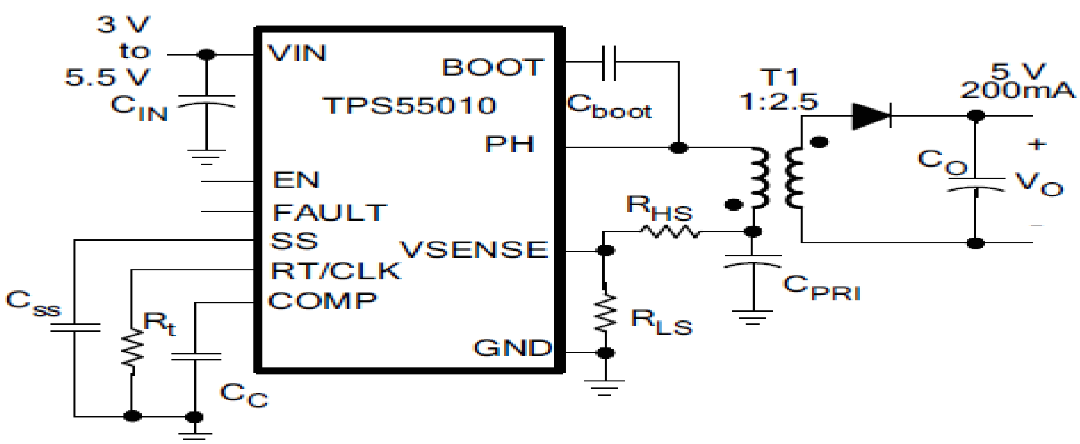


Figure 8.

More Details on the device application can be found in www.ti.com