

## **Variable-Speed Motor Controller Design Utilizing the LOC110**

## The Application

Variable speed controllers regulate the speed and/or torque of asynchronous motors. Depending on the application, there are controllers from a few hundred Watts up to several hundred Kilowatts. These speed controllers must conform to international standards and operate in industrial environments that are subject to high-energy overvoltages (surges), phase failure, overvoltages, undervoltages, and power supplies with high levels of noise interference. In this type of environment, the LOC110 linear optocoupler from IXYS Integrated Circuits Division excels. The LOC110 is a linear optocoupler that provides  $3750V_{rms}$  of input/output isolation with a high CMRR and high noise rejection ratio.

## The Circuit

In the photovoltaic mode (Figure 1) it is possible to get up to 12 bits resolution from the voltages you want to monitor on your attached microcomputer or personal computer, both of which can be remote. The output voltages, of course, are completely isolated from the mains.

When we look at Figure 1, we see that L1, L2, and L3 are the incoming line voltages up to  $240V_{rms}$  referred to the neutral wire, (N). These line voltages are the same for the upper and the lower circuit. (They are only separated for better understanding of the circuit).

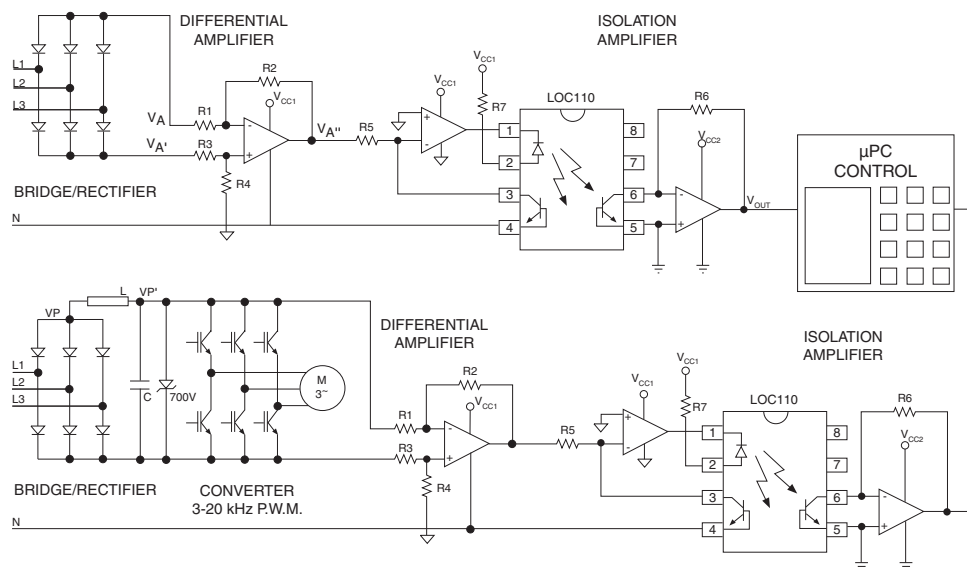


Figure 1

### Figure 1 - Upper Part: Monitors the line voltages and the (absence of) phases

The line voltages are rectified (waveforms Figure 2) with a bridge. The high voltage between  $V_{A'}$  and  $V_A$  is converted to a lower voltage with a differential (instrumentation) amplifier. The difference in voltage between  $V_{A'}$  and  $V_A$  is  $590V_{PEAK}$ .

The output of the differential amplifier is found to be:

$$V_{A''} = \frac{R4}{R3 + R4} \cdot \left(1 + \frac{R2}{R1}\right) \cdot V_{A'} - \left(\frac{R2}{R1} \cdot V_A\right)$$

$$\text{If: } \frac{R4}{R3} = \frac{R2}{R1} \quad \text{then: } V_{A''} = \frac{R2}{R1} \cdot (V_{A'} - V_A)$$

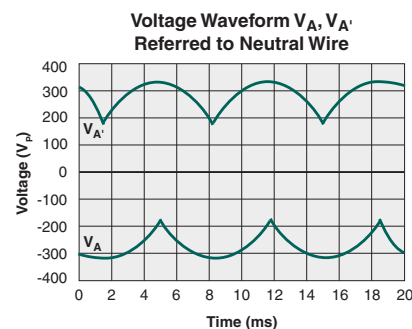
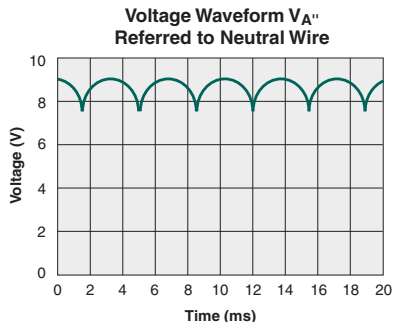


Figure 2

In our example (Figure 3) we used 1MΩ for R1 and 15KΩ for R2.



**Figure 3**

Voltage  $V_{A''}$  goes to the isolation amplifier (Figure 4).

The isolation amplifier is configured in the photovoltaic mode. Whenever you need a bandwidth not greater than 40kHz this is always the best configuration. This is because there are no dark currents in this mode, since there is no external power source connected. In the photovoltaic mode, the LOC110 phototransistors act as current generators. The LED flux is incident on the servo phototransistor which starts current  $I_1$  to flow from the op amp inverting input through the phototransistor. This servo photocurrent generated is linearly proportional to  $V_{A''}$ ,  $I_1 = V_{A''}/R5$  in order to keep the voltage on the inverting input equal to zero. The flux from the LED is also incident on the output

phototransistor which causes a current  $I_2$  to flow from the inverting input of the output op amp through the phototransistor. As  $I_2$  is pulled from the inverting node, the output of the amplifier begins to go high until a current equal in magnitude to  $I_2$  is injected into the inverting node of the amplifier. Because this current,  $I_2$ , flows through R2, an output voltage is developed such that:

$$V_{OUT} = I_2 \cdot R6$$

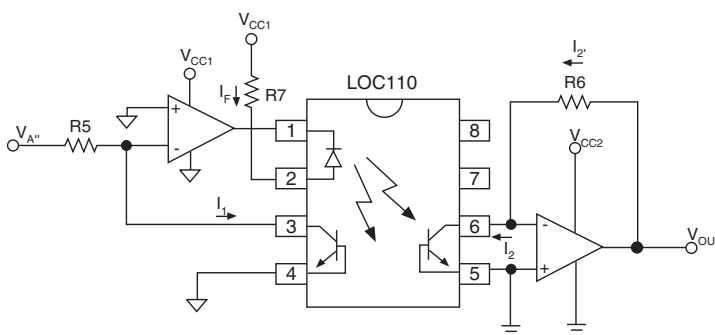
$V_{OUT}$  is also equal to:

$$V_{A''} \cdot K3 \cdot \frac{R6}{R5}$$

Depending on the bin number (A to J) you receive, an LOC has a K3 varying from 0.55 to 1.426. K3 is the transfer gain  $K2/K1$  where  $K1$  is the servo gain  $I_1/I_F$ ,  $K2$  is the forward gain, and  $I_F$  is the LED current flowing.

## Figure 1 - Lower Part: Monitors the power bus voltage (about 600 VDC)

The line voltages are again rectified, but instead of a few mA, currents up to several hundreds of Amperes are flowing. The ripple of voltage VP is rejected through the LC low pass filter. The voltage VP' is the actual power bus voltage. The zener diode is used to protect the capacitor from overvoltages when the machine suddenly reduces speed (brakes). The circuit after the zener diode represents the control circuit for the Pulse Width Modulation; modulation frequencies are typically between 3 and 20 kHz.



**Figure 4**

For additional information please visit our website at: [www.ixysic.com](http://www.ixysic.com)

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