APPLICATION NOTE AN-109

Variable-Speed Motor Controller Design Utilizing the LOC110

CLARE

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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 kWatts. These speed controllers must conform to international standards and operate in industrial environments which are subject to high-energy overvoltages (surges), phase failure, overvoltages, undervoltages and supplies with high levels of noise interference. It is in this type of environment that the LOC110 linear optocoupler from Clare excels. The LOC110 is a linear optocoupler that provides $3750V_{RMS}$ 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, which can be remote. The output voltages, of course, are completely isolated from the mains.

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

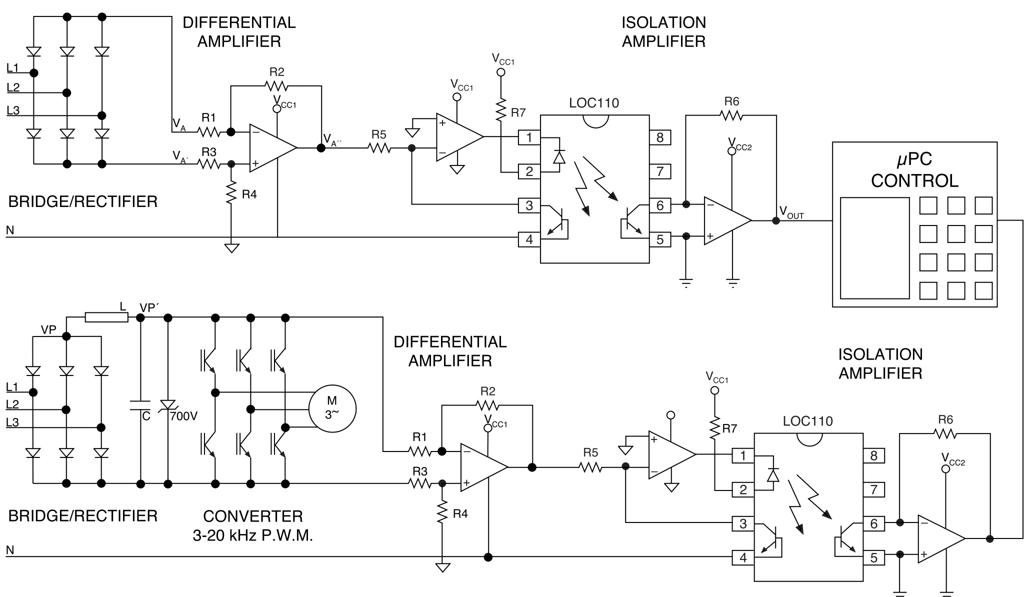

Figure 1

The upper part monitors the line voltages and the (absence of) phases.

The line voltages are rectified with a bridge (figure 2). 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:

$$V_{A''} = \frac{R_4}{R_3 + R_4} \cdot \left(1 + \frac{R_2}{R_1}\right) \cdot V_{A'} - \left(\frac{R_2}{R_1} \cdot V_A\right)$$

if , $\frac{R_4}{R_3} = \frac{R_1}{R_2}$, then it follows $V_{A''} = \frac{R_2}{R_1 \cdot (V_{A'} - V_A)}$.

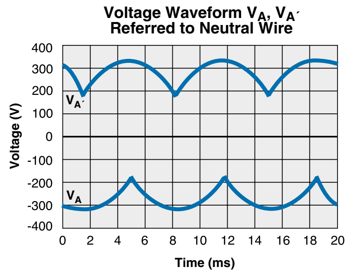

Figure 2

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

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 mainly due to the fact that 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 form 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. Since this current I_2 flows through R2 an output voltage is developed such that $V_{OUT} = I_{2'} \bullet R6$. V_{OUT} is also equal to $V_{A''} \bullet K3 \bullet R6/R5$. 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 and K2 is the forward gain and I_F is the LED current flowing.

The lower part of the circuit (fig. 1) monitors the power bus voltage (about 600 VDC).

The line voltages are again rectified, but instead of a few mA's, 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 with modulation frequencies mostly used somewhere between 3 and 20 kHz.

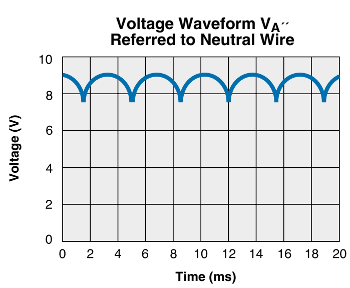

Figure 3

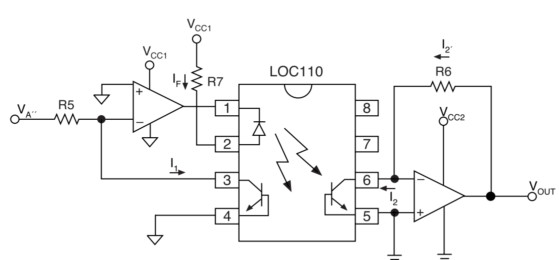

Figure 4

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For additional information please visit our website at: www.clare.com

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