

THE IL-300 LINEAR OPTOCOUPLER

by

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Optical isolators have been around for quite a few years now and are usually used in discrete circuits to couple on/off signals from one system to another. Using light to turn on an output device in the chip enables in excess of 2500 volts of isolation between the input and output. This kind of optocoupler can be found in many forms: AC and DC inputs and transistor, SCR and Triac outputs, just to name a few. Until now, the drawback to optocouplers was their inability to couple analogue signals. This is where the IL-300 Linear Optocoupler comes in.

The IL300 is an eight pin DIP IC that will couple linear signals from its input to output with .01 % linearity. It is very stable and gives over 7500 volts of isolation. This kind of performance is useful in a wide range of circuits but a couple of applications are particularly promising.

Switch mode power supplies are one example where the output is best isolated from the input. Figure 1 shows the block diagram of a typical switch mode power supply. Mains AC power is rectified and filtered, then switched at a higher frequency and applied to a transformer. The output of the transformer is again rectified and filtered giving the DC output of the supply. Output voltage regulation is accomplished by sensing the DC output and sending a signal back to the switch mode regulator that adjusts the duty cycle of the oscillator. If the

output voltage decreases the feedback signal causes the regulator to increase the ON time of the oscillator which increases the output.

Isolation between input and output is desirable here and the transformer provides that for the main part of the circuit. The feedback signal, though, should be isolated as well. In past circuits the output voltage signal was often converted to a AC signal in which the frequency was proportional to the voltage. The AC signal was then coupled back using conventional optocouplers or transformers.

The IL300 simplifies this by avoiding the voltage to frequency conversion used in the old systems.

HOW DOES IT WORK?

The input to the IL300 is an infrared light emitting diode. The output is a photodiode. Photodiodes can be used in one of two modes: photovoltaic or photoconductive. In this application the photoconductive mode is used. This means that the cathode of the diode is connected to a positive DC source and the intensity of the light hitting the diode will control a reverse current through it. The current flows through an external resistor creating a voltage signal.

Everything described so far could be done with a standard optocoupler with a transistor output. The problem with this method is that the input LED has a non-linear light

output so any analogue signal coupled through will have a non-linear transfer characteristic. The non-linearity relates to the 'knee voltage' of the diode. Until the .6 to .7 volt forward voltage drop is overcome very little current flows. After .7 volts, current flows easily and fairly linearly. Other non-linearities affect diodes as well. For instance, temperature fluctuations will change the characteristic of the diode. If the output photodiode doesn't track these variations, non-linearities occur.

To overcome these problems the IL300 has an additional photodiode included in the package that is used as a negative feedback element. This second photodiode is identical to the output photodiode and also operates in the photoconductive mode.

Figure 2 shows a typical circuit configuration using the chip. The LM201 op amp drives the input LED and receives a feedback voltage from pin 4, the feedback photodiode. The first basic rule of op amps is that they will always drive their outputs to attempt to bring their inputs to equal voltage. In this case, if some positive voltage (let's say 3 volts) is applied to the non-inverting input of the op amp, the output will drive positive. As the LED turns on, both photodiodes will receive infrared radiation. The feedback photodiode will then allow current to flow through it and R3 (30k) developing a voltage at the inverting input of the op amp. The op amp will continue to increase its output current drive until both inputs at 3 volts.

If exactly the same amount of light reaches both photodiodes, and if their sensitivities are identical, the output voltage across R5 (also 30k) would be equal to the input voltage. This would constitute a voltage

gain of one for the circuit. Due to the feedback, non-linearities in the input LED should not matter. Whatever voltage is applied to the input of the op amp, it will drive until the same voltage appears at its inverting input.

One other consideration remains, however. If there are differences in the sensitivities of the photodiodes, or if the same amount of light does not reach both of them, equivalent currents will not flow through them. This will not affect the linearity of the circuit but it will change the overall gain of the circuit. Figure 2 shows arrows depicting the infrared light coupled to each photodiode. K1 is a gain figure associated with the feedback diode; K2 relates to the output diode. The transfer gain of the chip (K3) is described as the ratio of these two gains: K_2/K_1 (assuming R3 and R5 are equivalent values). Considering the resistor values, the gain of the overall circuit will be: $K_3 \times R_5/R_4$

Thinking it through, these gains are just a mathematical way of expressing that more (or less) current may flow through the output diode if it is more sensitive, or receives more light, than the feedback diode. K2 and K1 are inherent in the chip from the factory but, because they do vary from chip to chip, they are tested and categorized. When you buy these chips K1 and K3 are specified by a alphabetic code on the chip.

As mentioned, linear optocouplers will be useful in switch mode power supplies but the applications won't stop there. Instrumentation transmitters, which typically use mod/demod/transformer type isolation between the field wiring and control room electronics, are a natural application. Maybe you have an application waiting for this kind of chip, too.

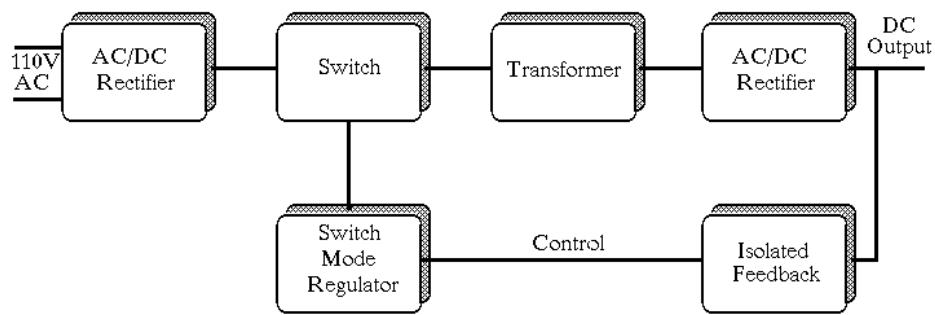


Figure 1. Switch Mode Power Supply

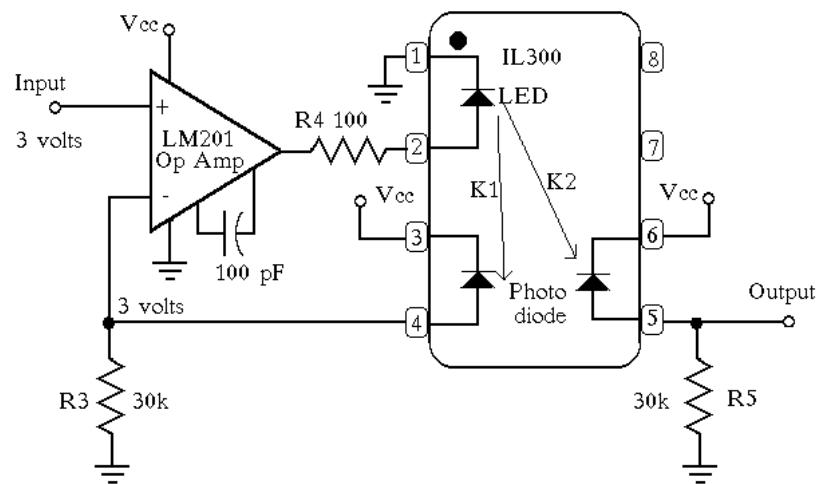


Figure 2. A Typical IL300 Circuit