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IMPROVED DEVICE NOISE PERFORMANCE FOR THE 3650 ISOLATION AMPLIFIER

By Bonnie Baker

The 3650 is an optically coupled, differential input, isolation amplifier having programmable gain. Noise for the 3650 is specified to 4µVrms (typ) on the input stage of the isolation barrier and 65µVrms (typ) on the output stage. The gain of the 3650 is controlled using external resistors on the input stage. In low gains, the noise performance of the 3650 is dominated by the output stage noise figure. The noise performance in high gains is dominated by the input stage noise. By using two OPA627s as a pre-amp to the 3650 isolation amplifier, the noise performance of the isolation circuit is greatly enhanced.

The input bias current noise contribution and the thermal noise of the gain resistors is relatively small and not included in the above calculation. E_{nO} includes the noise contribution due to the optics and the noise currents of the output stage. Because the 3650 uses optics as opposed to a carrier type modulation technique, there is no demodulation ripple at the output of the device.

The output-referred change in total noise vs gain is illustrated in Figure 2. Figure 2 graphically shows the noise performance of the 3650 with gains from 1 to 1000. For high

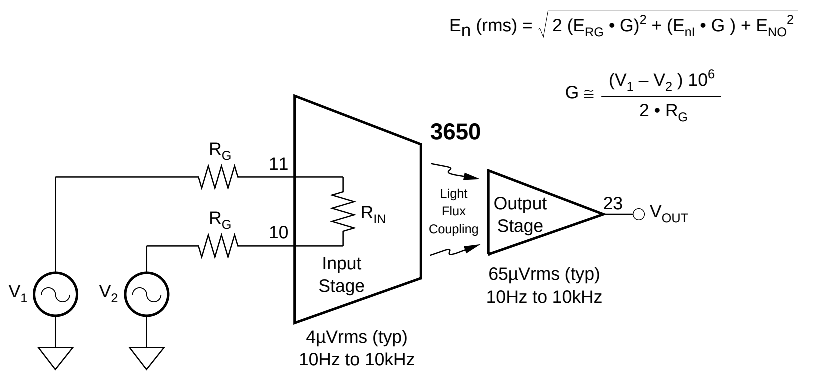

FIGURE 1. The 3650 Isolation Amplifier Has Differential Inputs and Adjustable Gain.

The 3650 has an input section, which can be gained by two external resistors (as shown in Figure 1), and an output section that is essentially kept in a unity gain configuration. The 3650's input noise performance is specified to 4µVrms (typ) times the gain over a 10Hz to 10kHz range. The output stage's noise contribution is 65µVrms (typ) from 10Hz to 10kHz. The 3650 gain can be adjusted from a gain of 1 to a gain of 1000 by adjusting the resistors, R_G. A first order calculation of the noise of the 3650 in various gains is shown below.

$$E_n\ (rms) = \sqrt{(2 \cdot (E_{RG} \cdot G)^2 + (E_{nI}G)^2 + (E_{nO})^2}$$

where:

E_n (rms) = total noise referred to output,

E_{RG} = rms noise of RG,

E_{nI} = rms noise of the input stage of 3650,

E_{nO} = rms noise of the output stage of 3650,

$$G = \frac{10^6}{2 \cdot R_G}$$

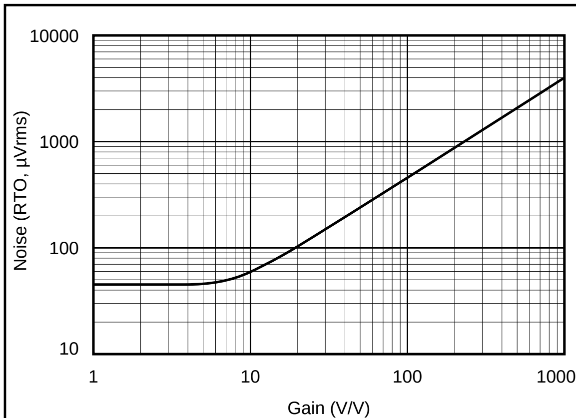

FIGURE 2. 3650 Noise (RTO) vs Gain of the 3650 Isolation Amplifier Shown in Figure 1.

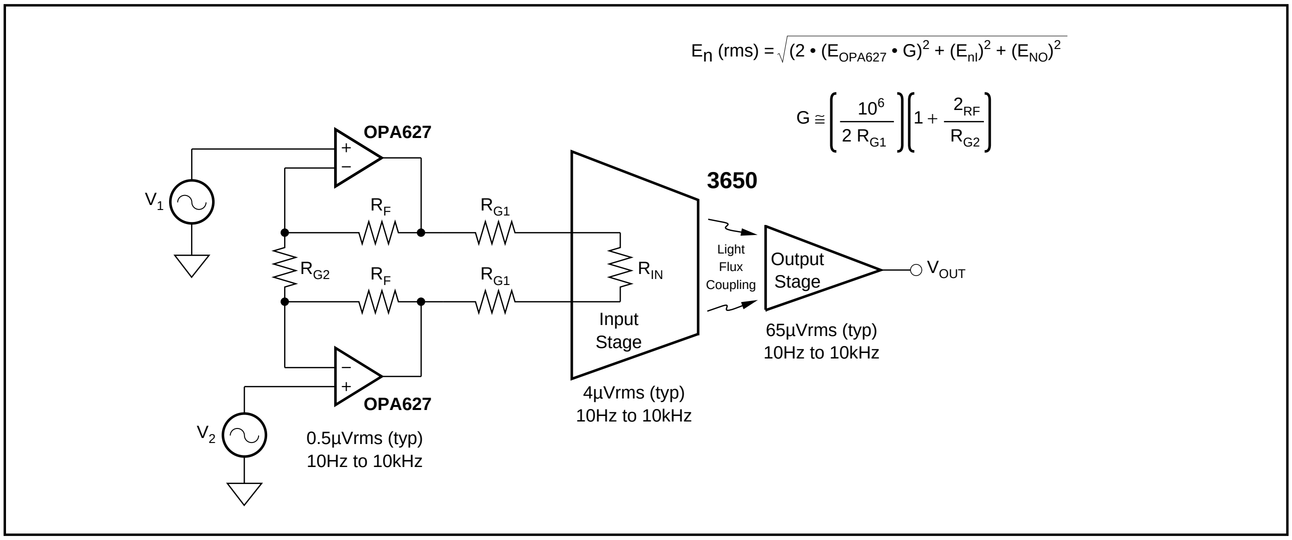

FIGURE 3. By Using Two OPA627s, Noise Performance is Improved for High Gains of the 3650.

values of R_G (or low input stage gains) the total noise referred to the output of the 3650 is dominated by the noise in the output stage, which is specified to 65µVrms (typ). As R_G decreases in value, the gain of the 3650 increases and eventually the noise in the input stage dominates due to the increase in gain. As shown in Figure 2, the effects of the input stage noise starts to dominate as the 3650 gain increases above 10V/V.

If the 3650 is applied in a low gain configuration, the noise referred to output will be optimized; however, it is possible to improve the noise performance in mid to high gains by using a pre-gain stage to the 3650. Figure 3 illustrates a configuration using the 3650 and two OPA627 amplifiers to improve the noise performance of the overall isolation solution. Here the OPA627 is selected because of its low noise performance characteristics; however, a variety of amplifiers could be used instead, depending on the noise requirements of the particular application. Two op amps are configured at the input to the 3650 to preserve the differential input and the programmable gain features that the 3650 offers. The total output noise calculation for this circuit is given by:

$$E_n\,(\text{rms}) = \sqrt{(2 \bullet (E_{OPA267} \bullet G)^2 + (E_{nI})^2 + (E_{nO})^2}$$

where:

E_n (rms) = total noise referred to output,

E_{OPA627} = rms noise the OPA627 operational amplifier,

E_{nI} = rms noise of the input stage of 3650,

E_{nO} = rms noise of the output stage of 3650,

$$G = \frac{10^6}{2 \bullet R_{G1}} \bullet \left(1 + 2 \bullet \frac{R_F}{R_{G2}}\right)$$

The change in total noise referred to output vs gain of the circuit in Figure 3 is shown graphically in Figure 4. The effects of the input stage noise starts to dominate as the 3650 gain increases above 50V/V, which is a significant improvement. If the application requires that the isolation amplifier have a gain of 2100, the improvement in noise performance is 3.4.

Noise is a typical problem confronting many isolation applications. By using a differential input stage constructed with two OPA627s, the noise performance of the 3650 is greatly improved for higher gains.

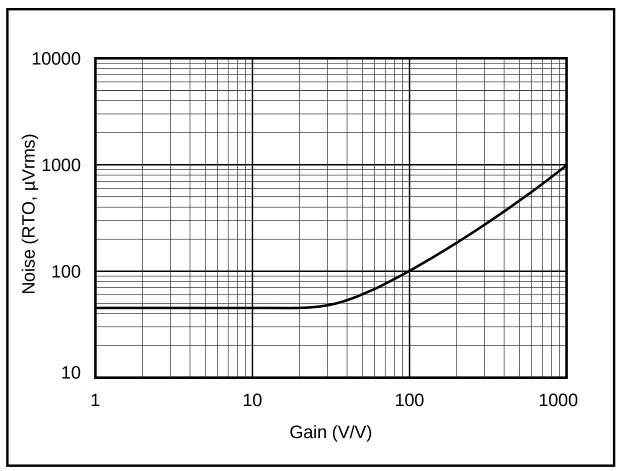

FIGURE 4. 3650 with OPA627 Pre-Amp Noise (RTO) vs Gain of the 3650 Isolation Amplifier with OPA627s Used for Gain as Shown in Figure 3.