

A Comprehensive Study of the Howland Current Pump



A Comprehensive Study

Figure 1

Figure 5

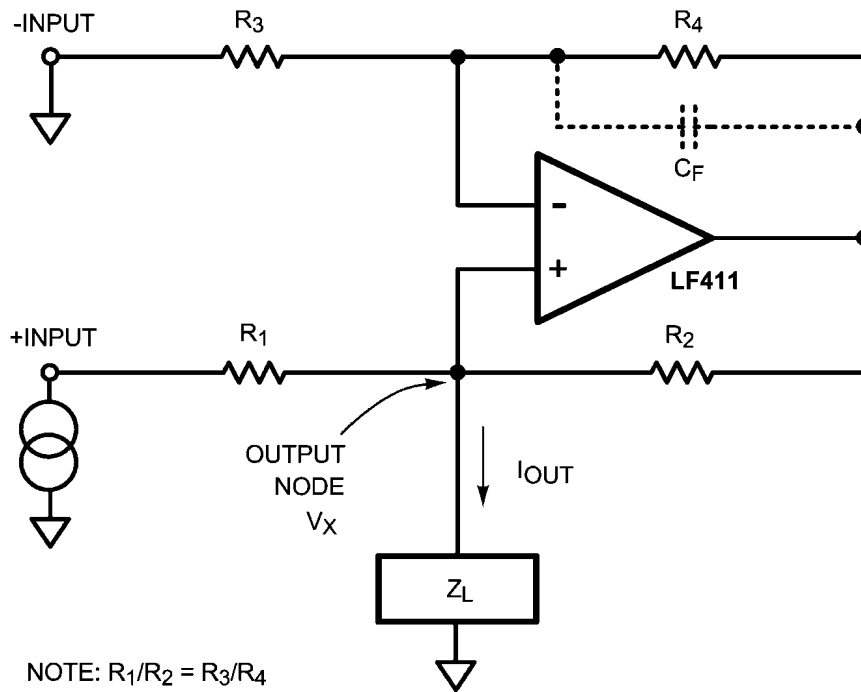


FIGURE 1. The Basic Howland Current Pump

Applications for the Howland Current Pump

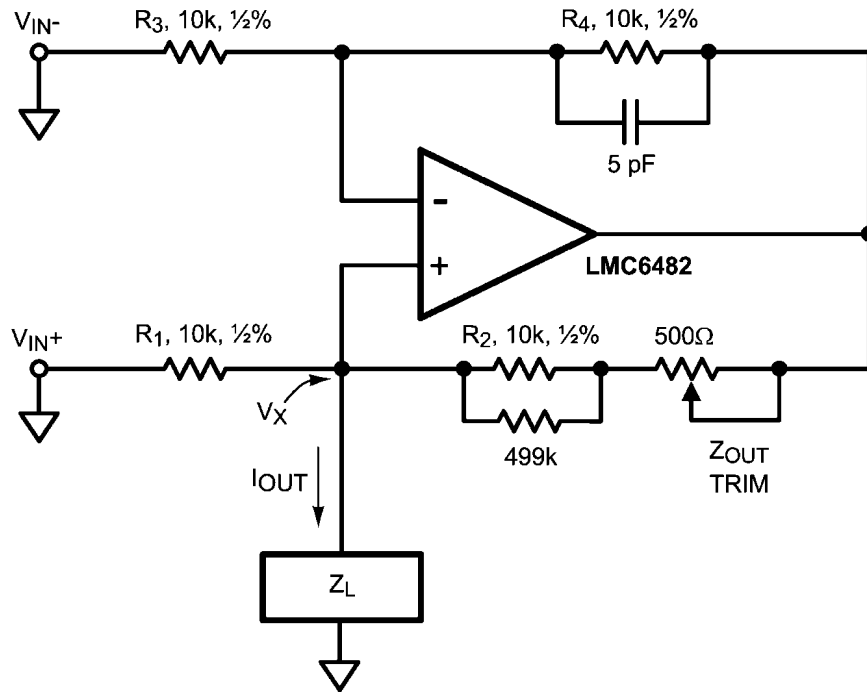
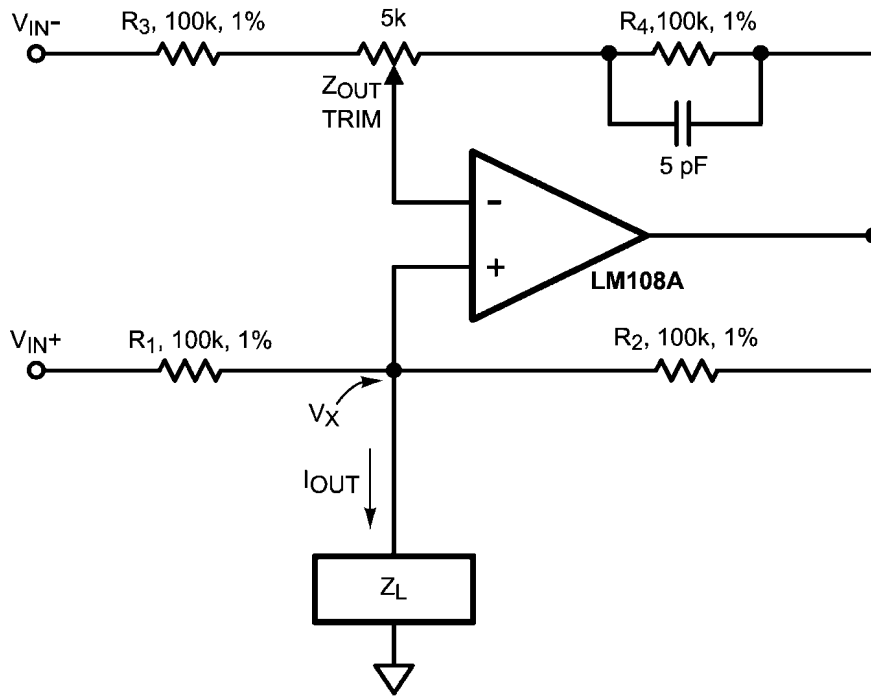


FIGURE 2. Basic Howland Current Pump with Trim of Z_{OUT}

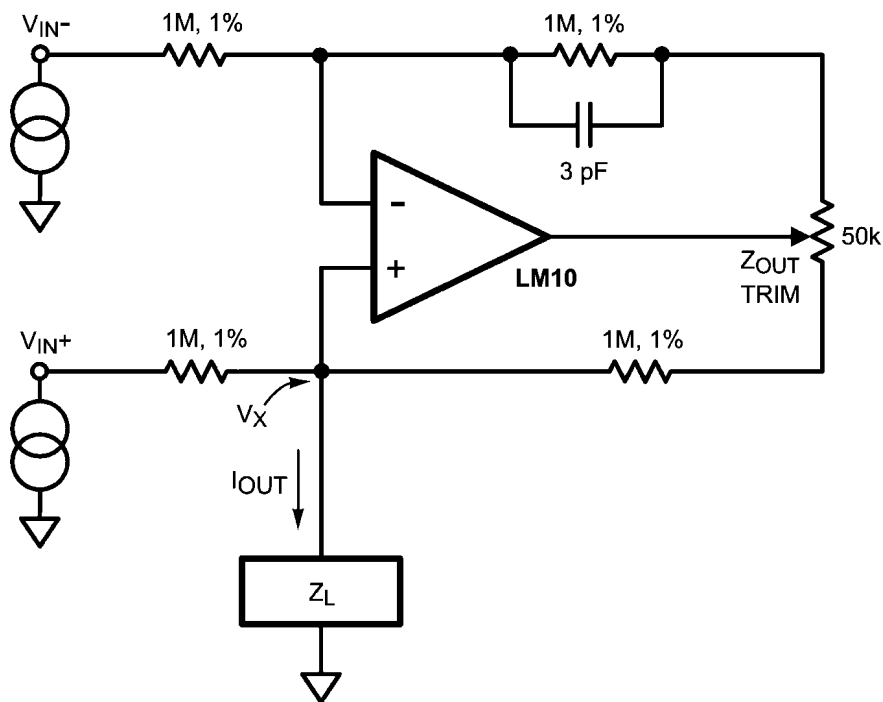
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Figure 2 Figure 3 Figure 4



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FIGURE 3. Basic Howland Current Pump with Trim of Z_{OUT}



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FIGURE 4. Basic Howland Current Pump with Trim of Z_{OUT}

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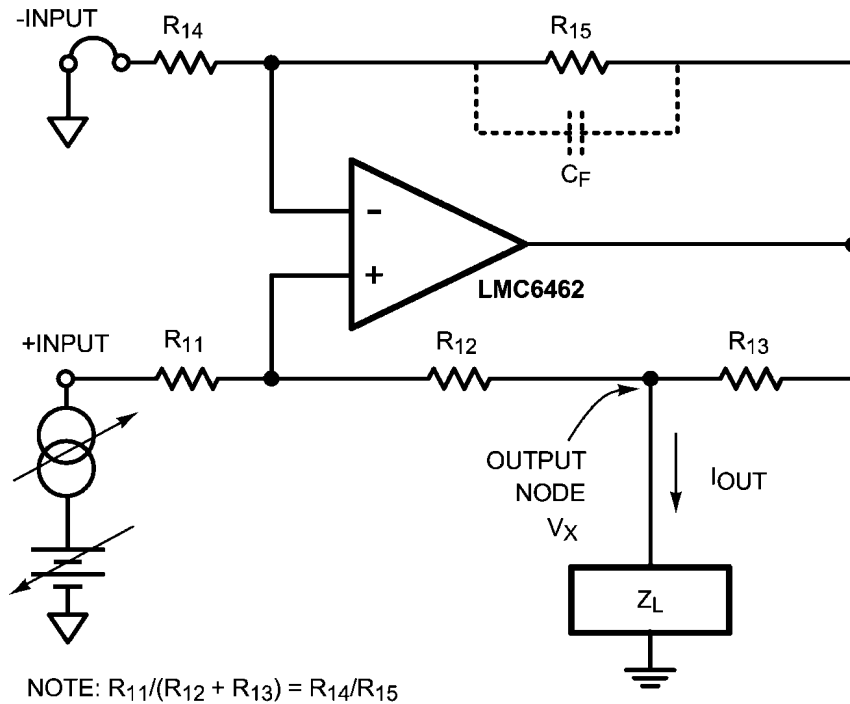


Figure 5

FIGURE 5. The "Improved Howland" Current Pump

The "Improved Howland" Current Pump

Figure 6

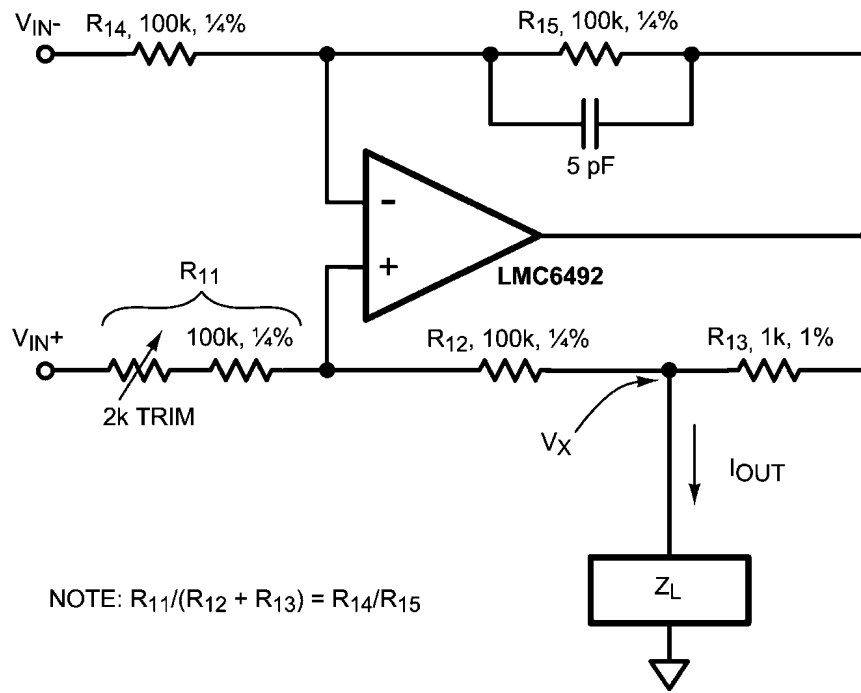


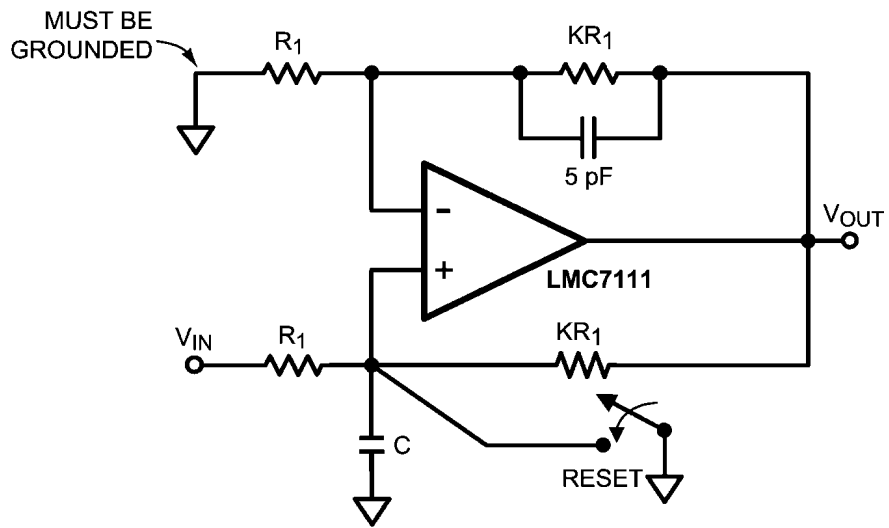
FIGURE 6. The "Improved Howland" with Trim for Z_{OUT}

Dynamics

Special Applications

The Howland Integrator

Choice of Amplifiers



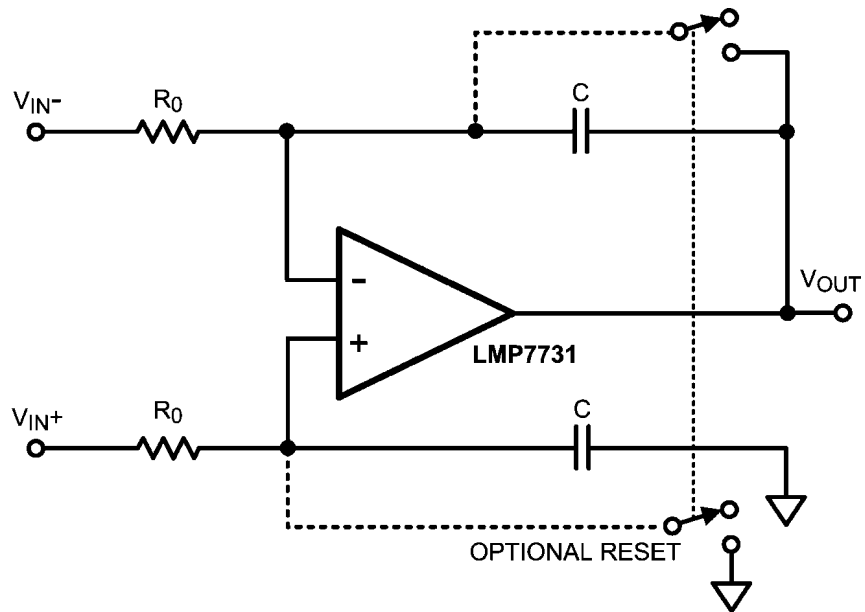
$$V_{OUT} = (1 + K) \frac{1}{(R_1 C)} \int V_{IN} dt$$

$$= \left(\frac{2}{R_1 C} \right) \int V_{IN} dt, \text{ if } K = 1$$

2 A

FIGURE 7. The Howland Integrator

Figure 8* is a differential integrator circuit using an LMP7731 op-amp. It features two input terminals, VIN+ and VIN-, each connected to the op-amp's inputs through resistors R0. The feedback network consists of two capacitors, C, one connected from the output to the inverting input and another from the output to the non-inverting input. An OPTIONAL RESET switch is connected to the junction of the two capacitors and ground.



$$V_{OUT} = \frac{1}{R_0 C} \int (+V_{IN+} - V_{IN-}) dt$$

2

FIGURE 8. The Positive or Differential Integrator (not a Howland Circuit)

Multi-Range Current Pump

Figure 9

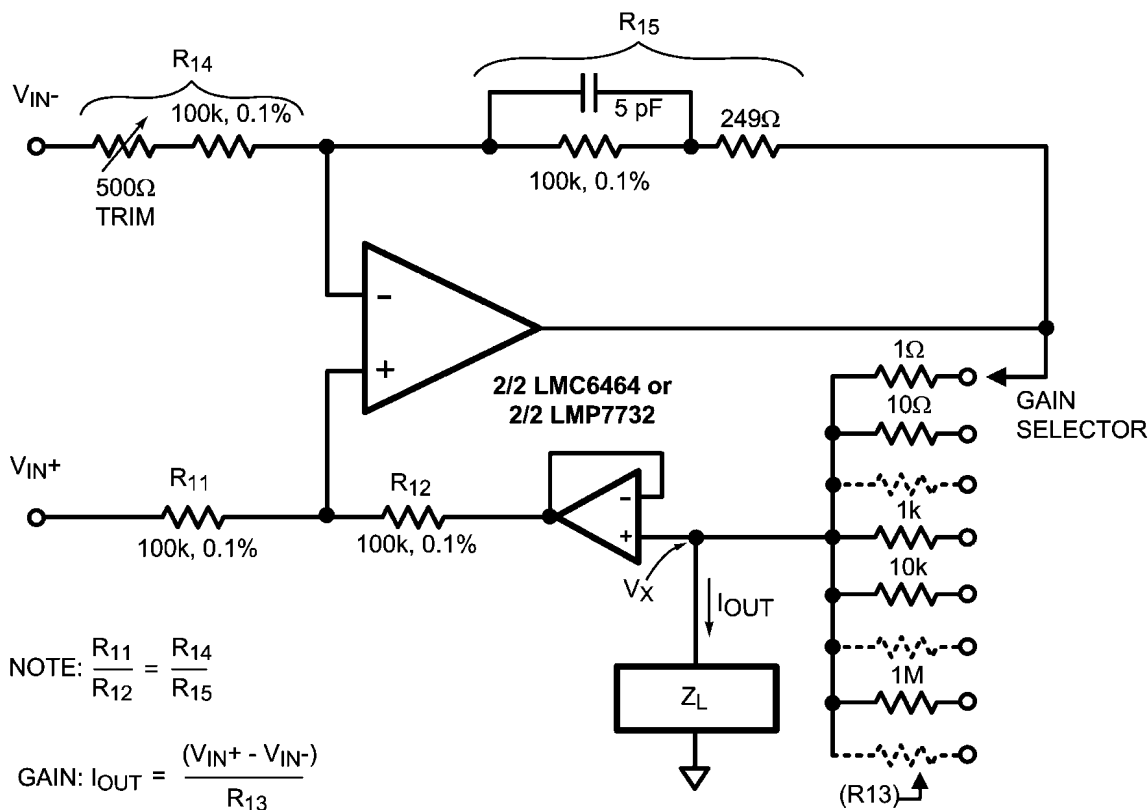


FIGURE 9. Multi-Range Current Pump

Appendix A. Output Impedance as a Function of Trimming

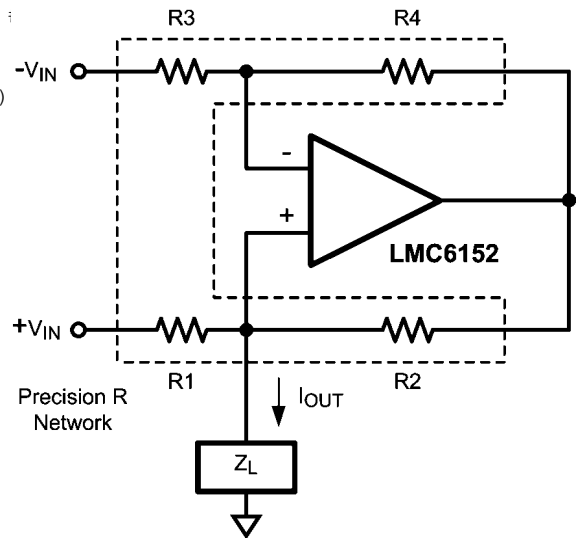
Applications for the Howland Current Pump

Figure 3

Figure 4

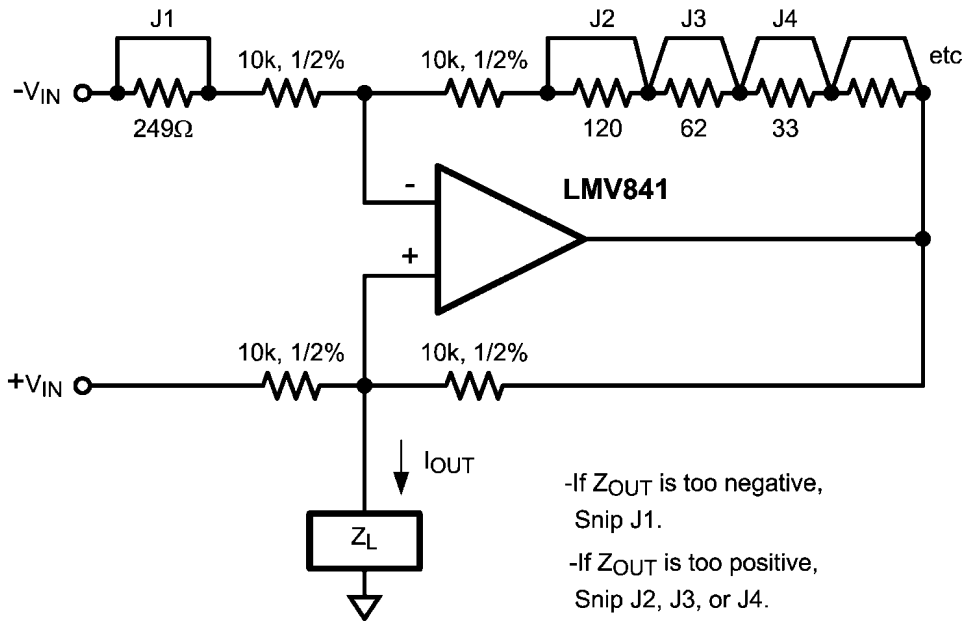
Figure 10

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 Figure 11



2 2

FIGURE 10. Basic Howland Current Pump with Precision Resistor Network



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FIGURE 11. Trimming Z_{OUT} without a Trim-Pot

Appendix B

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 &
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 S =9:) * =9: <)G * (A 9/-
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S =9 AA2) *
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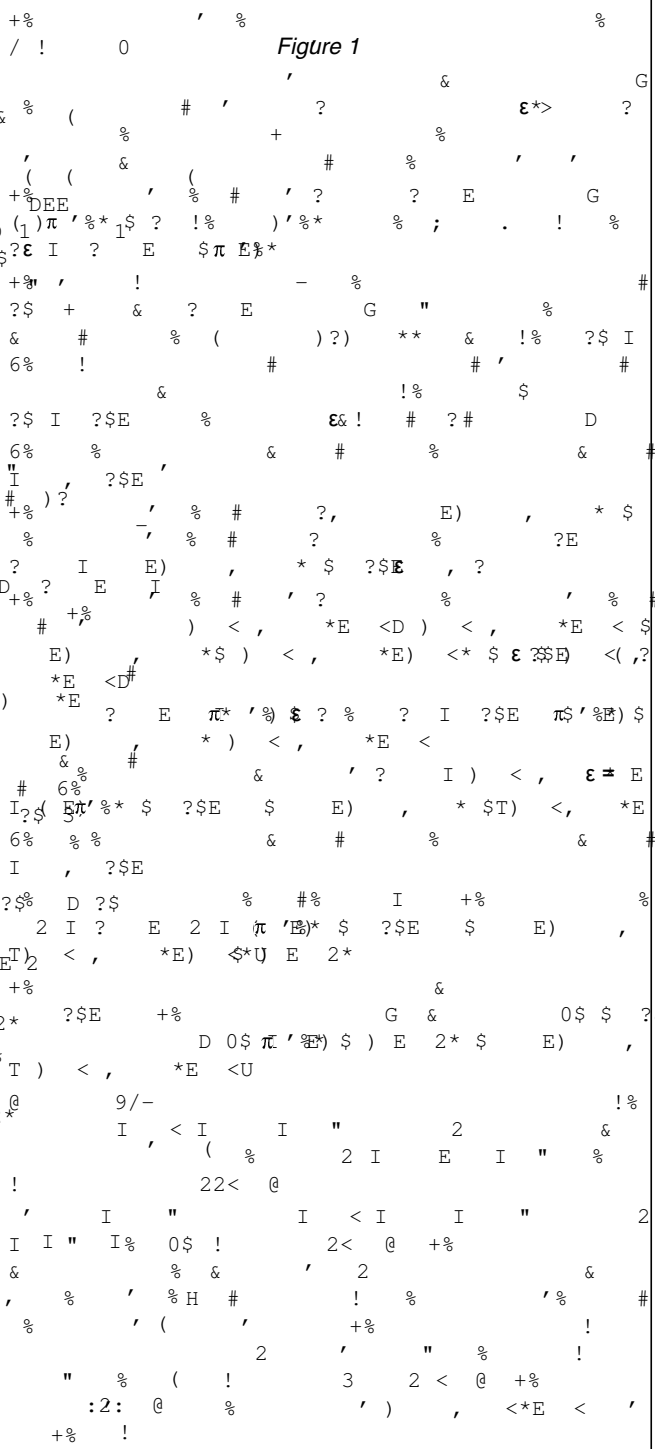
Appendix C

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Appendix E. Output Capacitance of the "Improved" Howland Current Pump

Figure 1

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Appendix D

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Appendix F. Testing and Trimming of Z_{OUT}

Figure 12

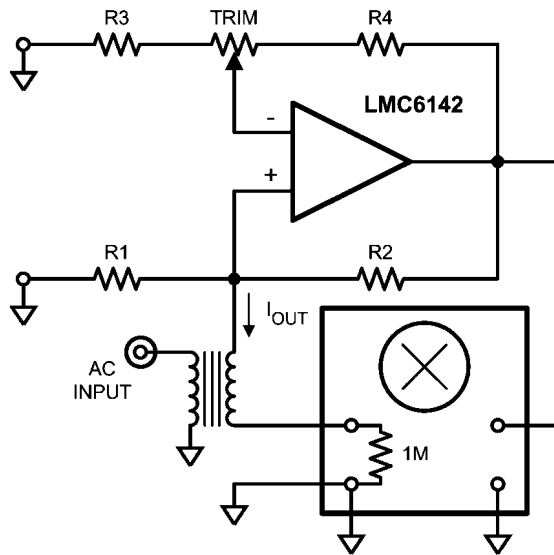


FIGURE 12. Transformer-Coupled Test for Z_{OUT}

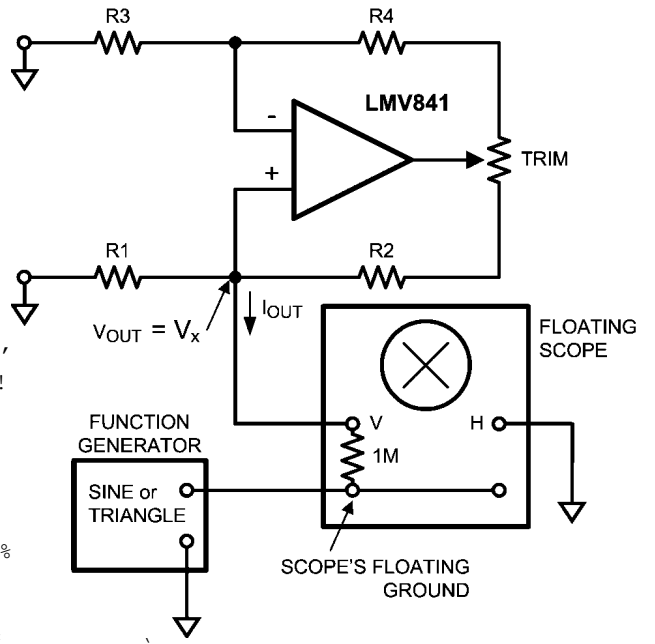


FIGURE 13. Good Test for Z_{OUT} Using Floating Scope

Figure 13

Figure 2 Figure 3 Figure 4

Notes

Notes

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 + C = 0C9 C > + .RN> /CR=4 C? 4> 4>WR +> 4> ; +> + ; 4 C > + ; @>;R 4
 >V0> + C? 4>4 + C =Y +> 9 4 0C 4 + C C@ => @C R0/ C4R0+ + C = R9> C
 = . = +N 6/ + C>?> 4 + C = 4 0= 9 N >V > C 9 = >4 6 +N >= + ; +C +/> =>
 4EC R > C@ + C = C4R0+ 0=R4 ; = . = +N C 6 + > >= + ; +C @ + > @C + 0R=
 R C > 9> 0/ + . = +N C @ ;>9> + C@ N +> + 0C N ;/+ C C+/> +>==>0R = C > +N
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