Instrumentation Amplifiers

Cascading Instrumentation Amplifiers for High Gain at High Bandwidth

Abstract

This application note explains cascading instrumentation amplifiers for high gain at high bandwidth.

Related Literature

For a full list of related documents, visit our website:

- ISL28533, ISL28534, ISL28535, ISL28633, ISL28634, ISL28635 device pages

1. Cascading Instrumentation Amplifiers

Although the prevailing number set in electronics is binary, a human-machine interface uses a decimal-number set. For this reason, designs often require the use of amplifiers with programmable gain steps in the power of 10. The ISL28634 monolithic instrumentation amplifier (Figure 1) has 9 digitally programmable gain settings, which are listed in Figure 2.

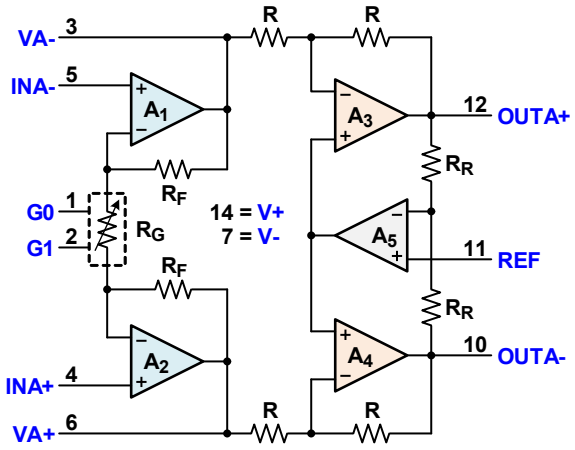
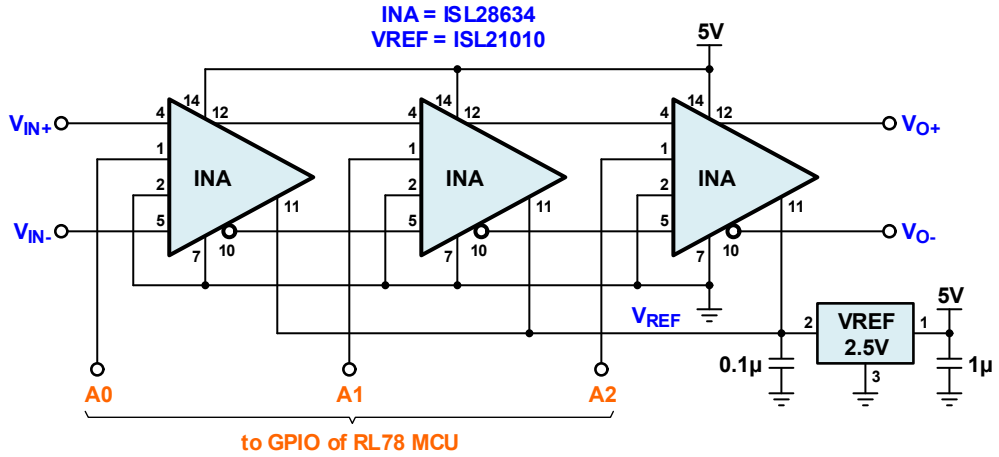


Figure 1. ISL28634 Block Diagram

G1	G0	Gain (V/V)
0	0	1
0	Z	2
0	1	10
Z	0	50
Z	Z	100
Z	1	200
1	0	300
1	Z	500
1	1	1000

Figure 2. ISL28634 programmable Gain Settings

The device has high bandwidth at lower gains, but inevitably loses this bandwidth at a gain of 1000. If an application demands bandwidth in the range of 100kHz at a gain of 1000 and if offset and noise performance prevail over circuit complexity, the cascaded amplifier in Figure 3 fits the need.



A0	A1	A2	Gain
L	L	L	1
H	L	L	10
H	H	L	100
H	H	H	1000
L	L	H	10
L	H	L	10
L	H	H	100
H	L	H	100

Figure 3. Cascaded Instrumentation Amplifier Achieves 136kHz Bandwidth at Gain of 1000

This composite instrumentation amplifier uses three cascaded ISL28634 devices. Each device has its G1 terminal fixed to ground; therefore, enables a gain change between 1 and 10 by turning the G0 terminal high or low. The three G0 terminals are designated with A0, A1, and A2, which are controlled through the GPIO of the local controller. The required logic states and their corresponding gain settings are listed in Figure 3.

Figure 4 shows that the bandwidth for the single INA at G = 10 (20dB) is 237kHz. This bandwidth is reduced to 2.37kHz at G = 1000 (60dB). Cascading three INAs, each working at G = 10, partially restores the bandwidth to 136kHz while operating at G = 1000.

Figure 5 depicts the corresponding, input-referred (RTI) voltage noise densities. Here, the single INA, at G = 10, has nearly twice as much low-frequency noise as the cascaded amplifier operating at G = 1000.

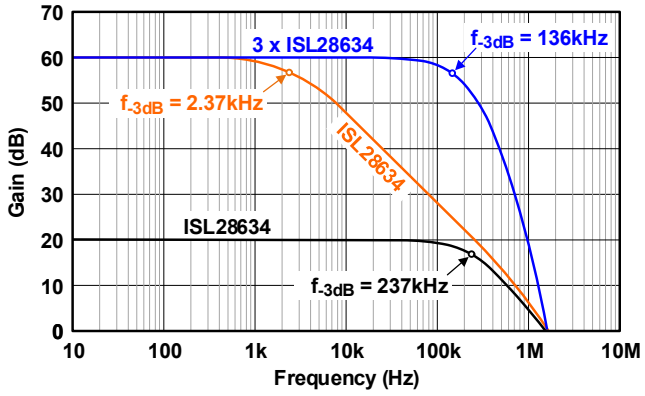


Figure 4. Gain Responses for Single and Cascaded Instrumentation Amplifiers

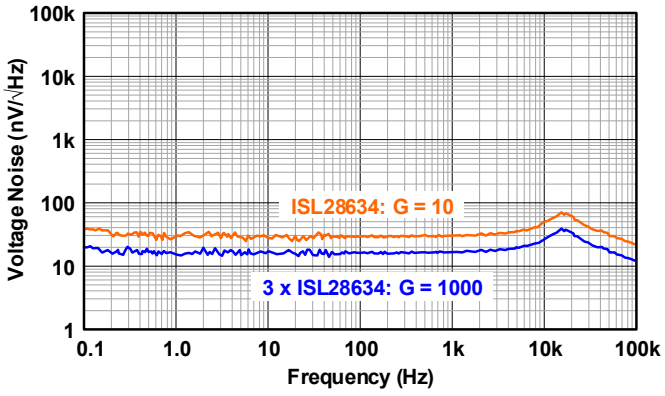


Figure 5. Input Referred Voltage Noise for Single and Cascaded Instrumentation Amplifiers

2. Revision History

Rev.	Date	Description
1.00	May.18.20	Initial release

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