Shielding & guarding

[AN-347]

“Electrostatic” shield

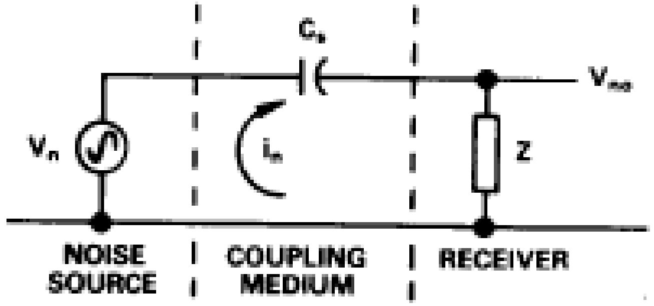


Figure 2. Equivalent circuit of capacitive coupling between a source and a nearby impedance.

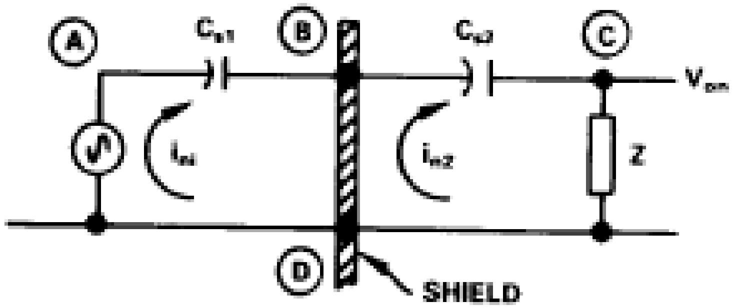


Figure 3. Equivalent circuit of the situation of Figure 2, with a shield interposed between the source and the impedance.

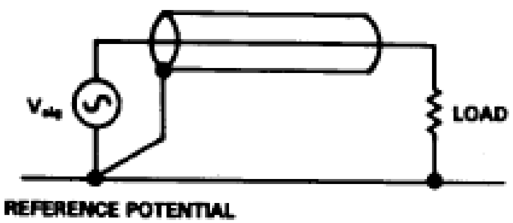


Figure 4. Grounding a cable shield.

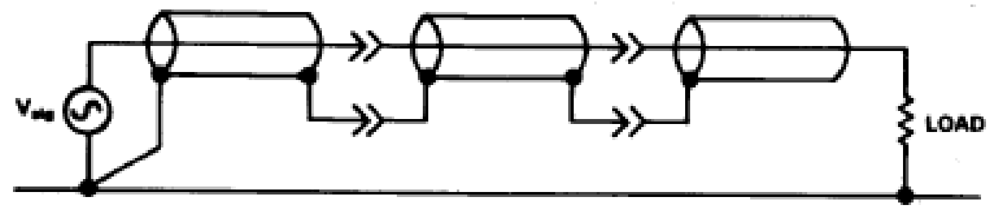


Figure 5. Shields must be interconnected if interrupted.

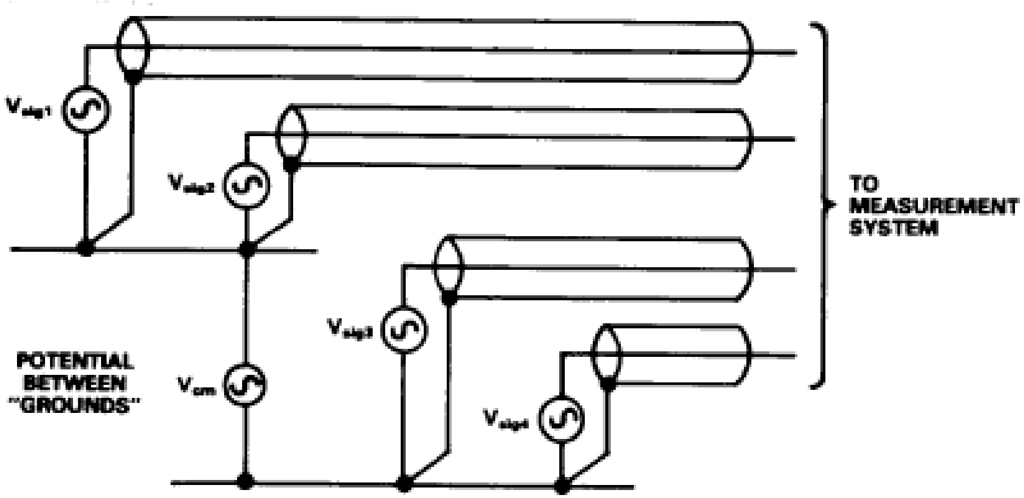


Figure 6. Each signal should have its own shield connected to its own reference potential.

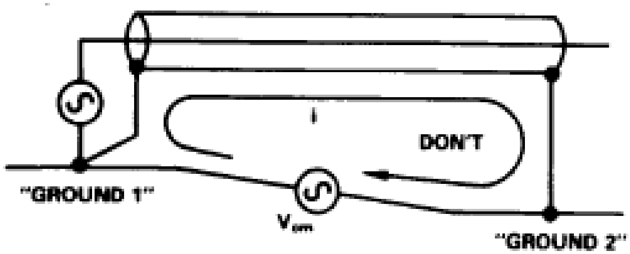
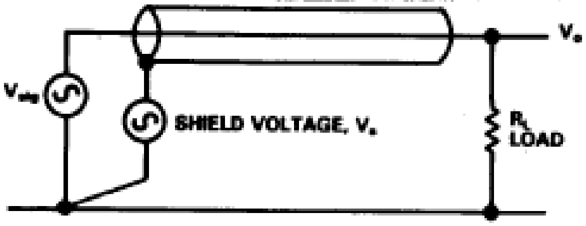


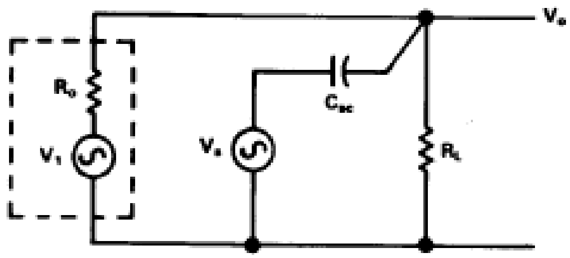
Figure 7. Don't connect the shield to ground at more than one point.

- The potential between the two grounds will cause a shield current to flow
- shield current will induce a noise voltage into the center conductor via magnetic coupling

- In general, *don't allow shield current to exist* (but see an exception later)
  - again, shield current would induce a noise voltage into the center conductor



a. Shield at potential V_S.



b. Equivalent circuit.

Figure 8. Don't permit the shield to be at a potential with respect to the signal.

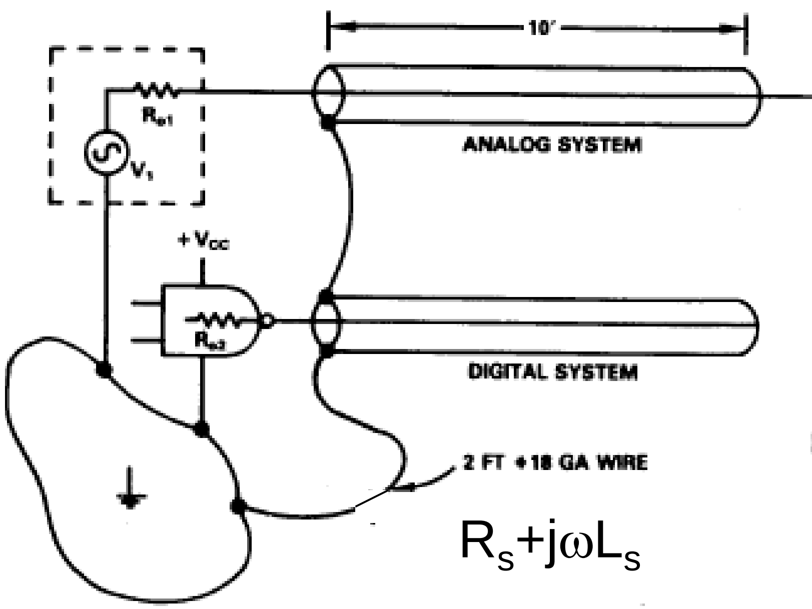


Figure 9. A situation that generates transient shield voltages.

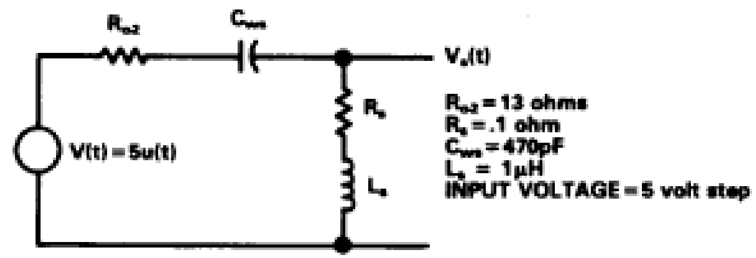


Figure 10. Equivalent circuit for generating shield voltage.

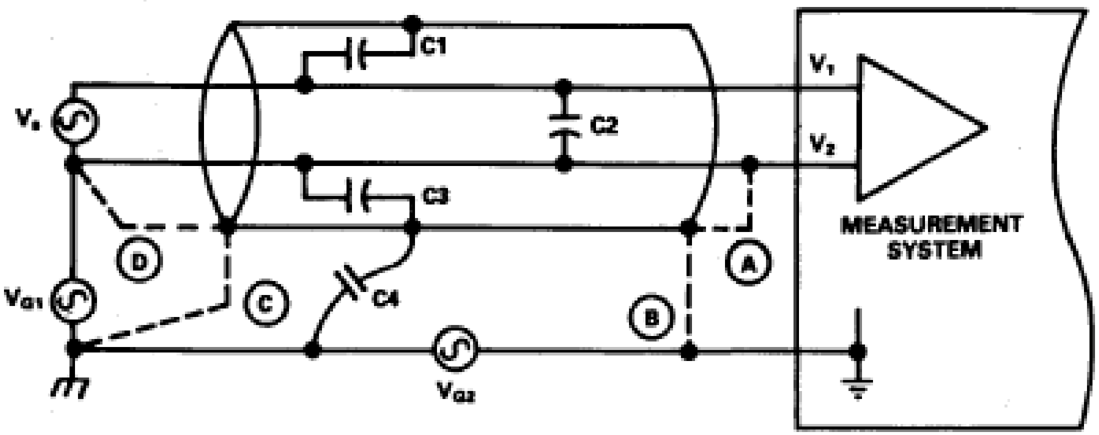
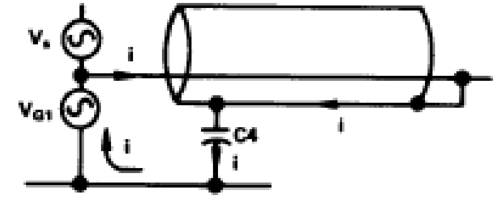
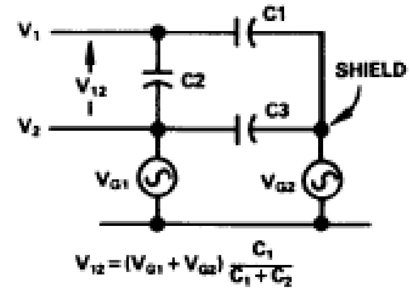


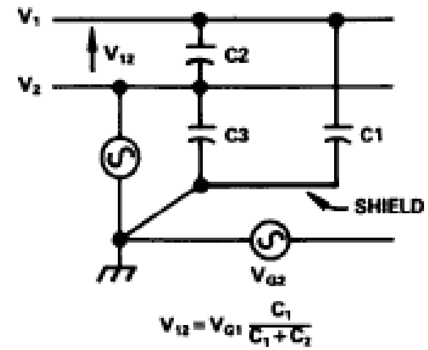
Figure 12. Possible grounds where system and source have differing ground potentials.



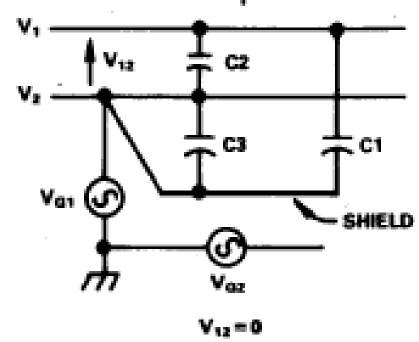
a. Return path A.



b. Return path B.



c. Return path C.



d. Return path D.

Here, D should is the best choice...

Magnetic shields

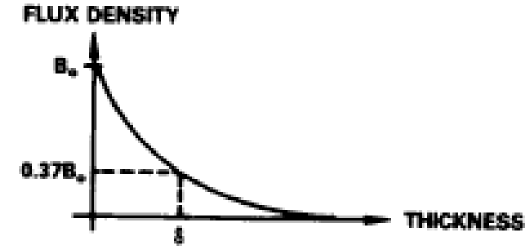


Figure 14. Magnetic field in a shield as a function of penetration depth.

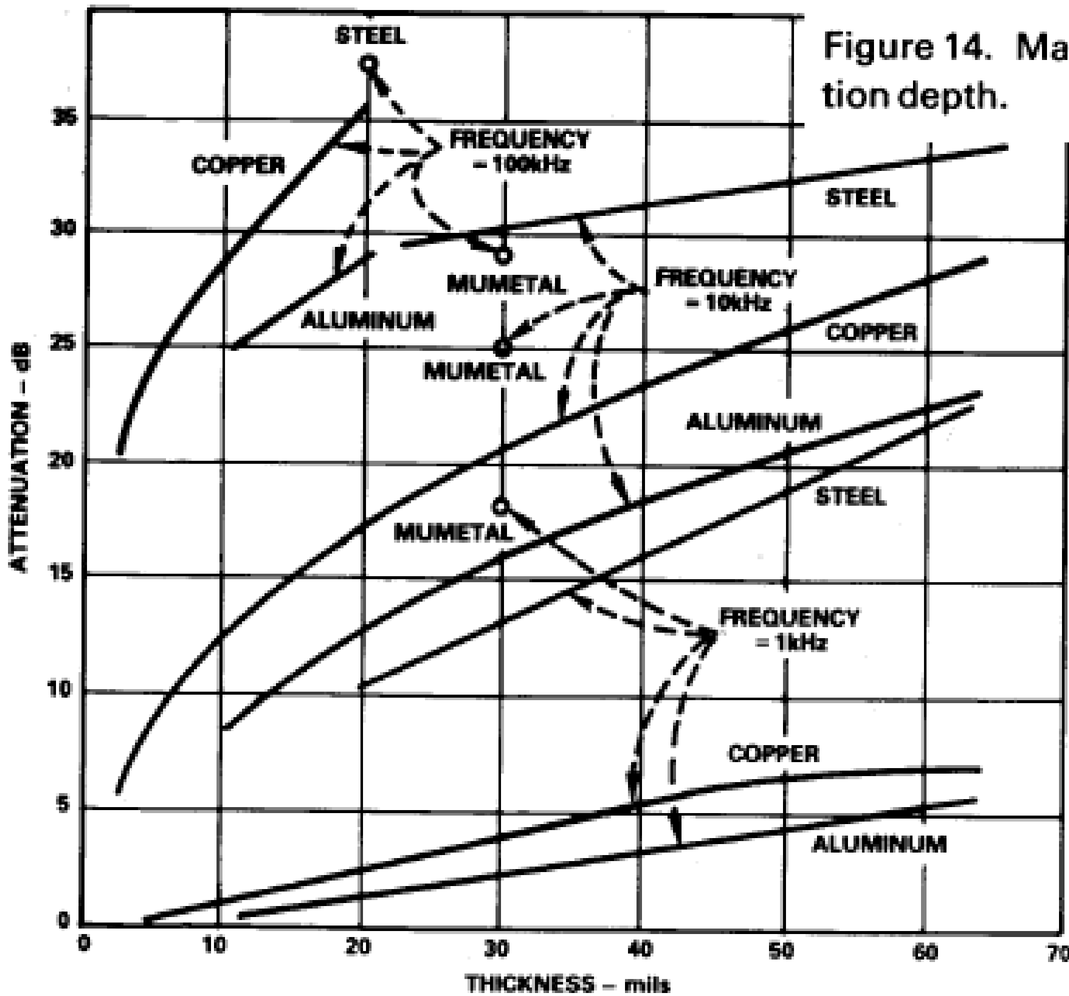
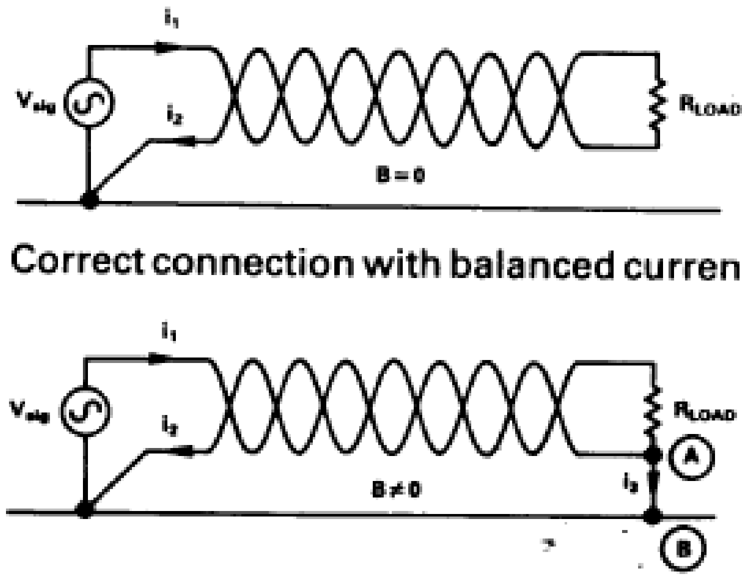


Figure 16. Shielding attenuation of Mumetal and other materials at several frequencies.



a. Correct connection with balanced currents.

b. Incorrect connection forming ground loop.

Figure 17. Connections to a twisted pair.

Note: ground connection between A and B could be unwanted: e.g. stray capacitance from R_{LOAD} to ground

- Shield current should be equal (and opposite) to center conductor current -> fields cancel out
- this seems to violate the «no shield current rule»:
- concentric cable is not used to shield the center lead; instead, geometry produces cancellation

- This approach is followed in this example (automated test equipment (ATE)) for the high-current logic supply for the ADC

Figure 18. Use of shield for return current to noisy source.

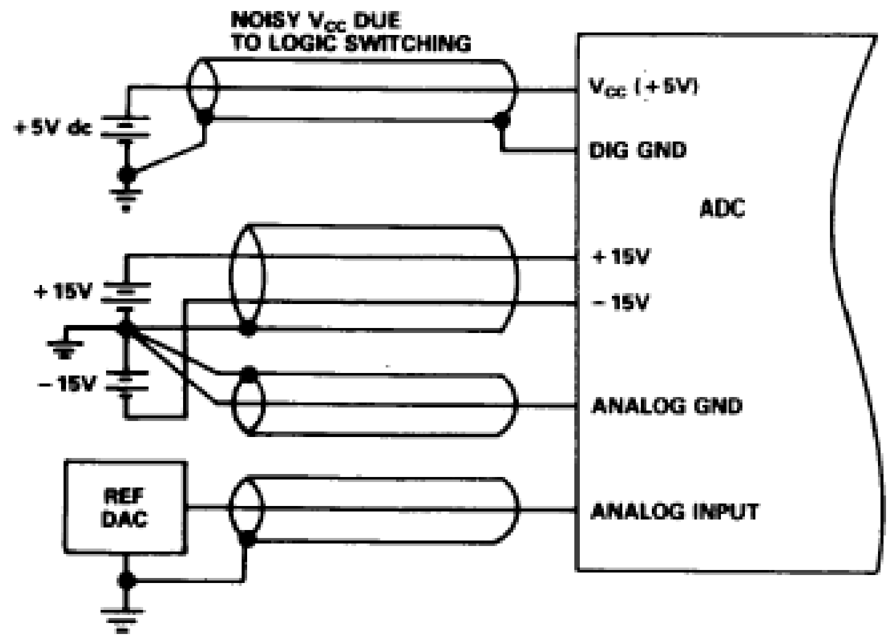


Figure 19. Application of circuit of Figure 18 in a test system.

Driven shields: guards

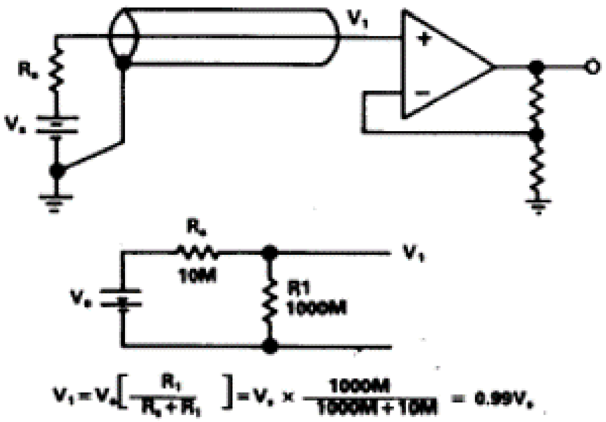
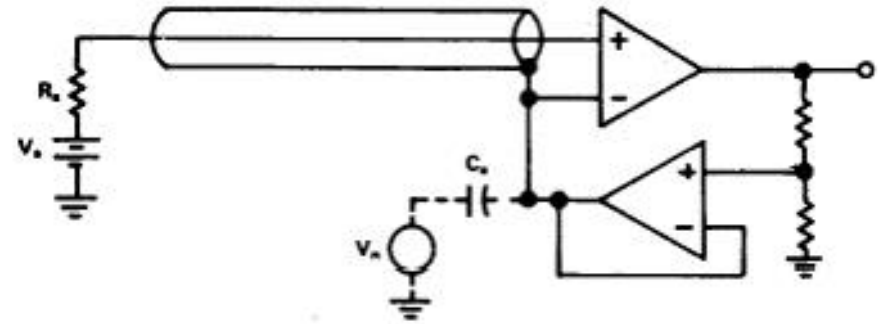
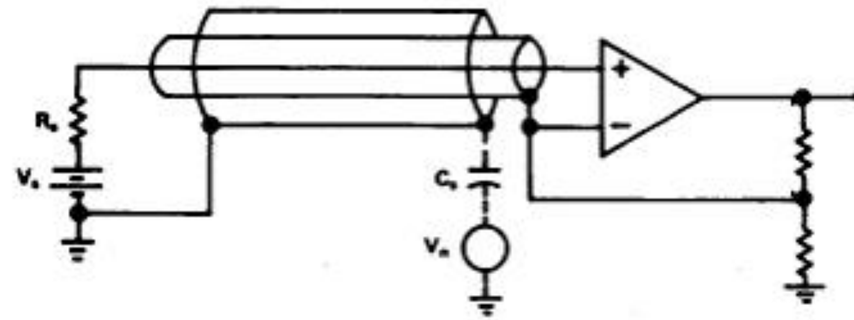


Figure 21. Op amp connected as high-impedance non-inverting amplifier with gain, with shielded input lead.



(a) Driven guard.



(b) Shielded guard.

Figure 23. Avoiding noise pickup on the guard.

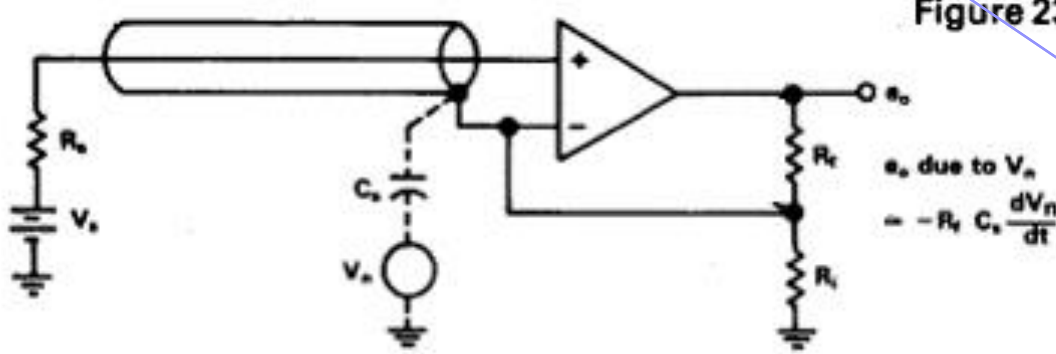
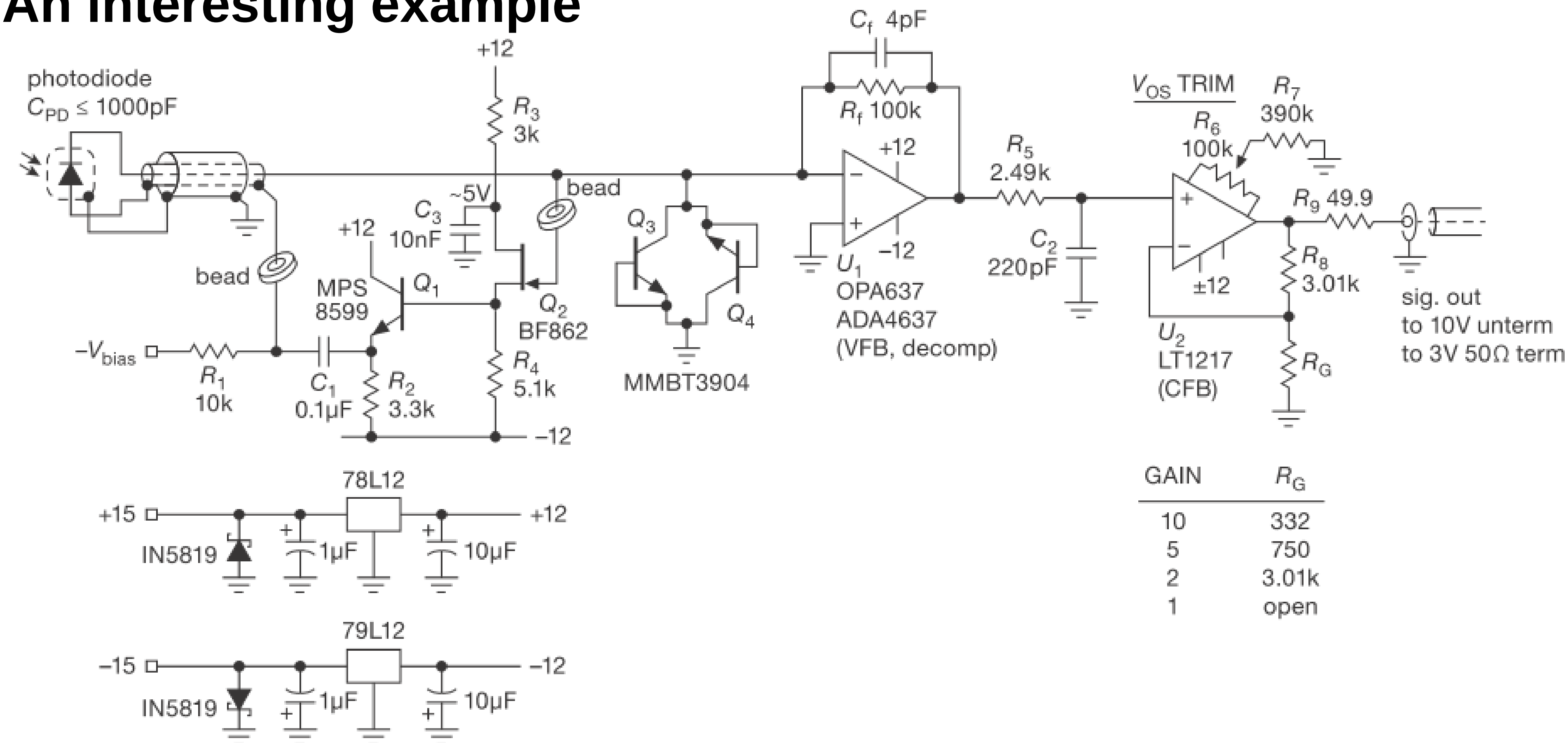


Figure 22. Same as Figure 21, but cable shield connected as a guard.

Note that the cable capacitance produces a substantial lag time constant $R_s C_c$.

An interesting example



A complete photodiode amplifier, suitable for input capacitances up to 1000 pF. Input bootstrapping greatly reduces the effective photodiode and cable capacitance, for enhanced speed and reduced noise [Horowitz, The art of Electronics - the X chapters, chap. 4]