Alan Martin, Engineer Extraordinaire, once told me, “You never regret adding isolation between your circuits.” While he was speaking in the context of power supplies, the same goes for isolating analog or different digital sections of your circuits. There are many accepted ways to achieve isolation. These days, rather than try to make an isolated analog signal chain, many engineers send isolated power to an ADC (analog to digital converter). They then use a digital isolator to allow the serial digital output to cross the boundary back to the main circuit.

Don’t overlook using fiber optics to achieve isolation. The Navy learned to love optical fibers since they are insensitive to EMP pulses from nuclear weapons. Glass fibers are expensive, and you can expect to pay 25 to 100 dollars for the transmitters and receivers. Then again, glass fibers work to GHz frequencies. A much more cost-effective solution is plastic optical fiber (POF). Here data rates are limited to 10 or 100 MHz, but the costs are closer to 5 dollars for transceivers.

Another major advantage is that you can use existing consumer fiber, like the TOSLINK cables used in high-end audio receivers (Figure 1). Most new televisions provide an audio output using the optical TOSLINK standard. PC laptops sometimes combine the 3.5mm audio jack with an LED, so you can use a small adapter to convert to the TOSLINK connector (Figure 2). There are also cables available with Mini TOSLINK on one end and a regular TOSLINK on the other. Toshiba has a good overview of its plastic optical fiber systems (PDF).
**Figure 1** TOSLINK, short for Toshiba Link, is a popular plastic optical fiber used in audio and TV equipment. (Source: [Wikimedia user Hustvedt](https://commons.wikimedia.org/wiki/File:TOSLINK connecting plug.jpg))

**Figure 2** In addition to the JIS F05 TOSLINK connector, you can run plastic optical fiber into a 3.5mm audio jack. This converter allows you to use a conventional TOSLINK cable. (Source: [Monoprice](https://www.monoprice.com/products/28617-3.5mm-adapter-for-toslink.html))

Combine a Toshiba TOTX1350 transmitter and a TORX1350 receiver and you can send data at 10Mbps. The modules cost about 7 bucks, and you can plug in any TOSLINK cable, including one from the Radio Shack down the street. That $15 cable could provide kilovolts of isolation as long as you ensure no creepage down the length of the cable.

The TOSLINK standard uses the JIS F05 connector. While cheap, it also has no positive retention. So you can use an SMA plastic optical fiber cable (Figure 3). This is used in industrial standards like Sercos. This standard also supports glass fibers that can carry much higher speeds. Glass fibers will take the price from 5 bucks a cable to 50 bucks. You can also adapt automotive plastic optical fiber designs as used in standards like MOST bus that carry 50 to 150Mbps traffic. With these speeds you can transmit digital video signals over 20 meters.
The Sercos industrial communication standard allows for plastic optical fiber that uses SMA-style threaded connectors. (Source: Industrial Fiber Optics)

The low cost of plastic optical fiber is a real plus. You can get a 6-meter cable with Versalink connectors for less than 4 bucks. Since Versalink is an industrial standard, you can expect to pay more for transceivers, but cable cost is often a major factor in the BOM (bill of material) cost. One thing to keep in mind is that POF is simplex, or one-way in nature. When you order and use duplex POF cable, it is simply a pair of optical fibers molded into one jacket and terminated by two separated fiber ends.

An even slower optical isolation is MIDI (musical instrument digital interface). The standard’s data-rate is 32kbps, but the transceivers will handle faster frequencies should you be willing to push it. Here the cables are copper, but they feed into an optocoupler on the receiver end (Figure 4). All the current is differential. There is no current that can exchange between the connected circuits, and therefore ground loops are eliminated. You would not use this for high-voltage isolation. The copper in the cable will carry any kilovolt potentials into your experiment where it would short into your circuits. Still, MIDI is a great way to use cheap consumer technology to isolate to low-voltage circuits, just what it does in musical instruments (Figure 5).

Figure 4 The MIDI standard uses copper cables but dictates an optocoupler in the receiving end to provide isolation. (Source: Wikimedia user Dr. Crash) Click to enlarge.
Figure 5 The MIDI interface specifies In, Out, and Thru connections. It connects musical instruments and audio equipment together while eliminating ground loops. (Source: YouTube/Michael Capoccia)

Don’t discount physical connections. While wireless technology is ascendant, it can never be as reliable or as secure as a physical connection. As more and more wireless gizmos invade the home, office, and factory, there is more likelihood of interference. Physical connections are naturally more secure since you are not broadcasting the data over a large area. Besides EMP resistance, the Navy loves fiber optics since it is much harder to snoop on an optical connection. So if you need a way to make an isolated system, keep in mind using cheap plastic optical fibers. It won’t run a kilometer, but it might stretch far enough to solve your problem, even if that is only a few inches on a circuit board.

Also see:

- Isolated USB-to-UART converter builds in 20 minutes for $20
- Designer's Notebook: Signal Isolation
- Inexpensive analog isolation using a digital isolator
- Understanding isolator standards and certification to meet safety requirements
- Serial buses: Faster than cars
- Milestones That Mattered: Fiber optics: The railroad of the communications boom