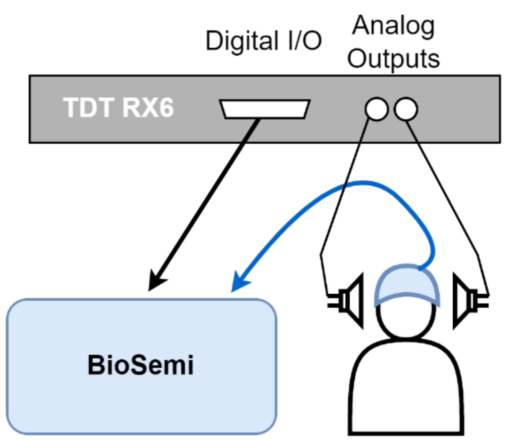
Biosemi trigger line optoisolation

Purpose

Part of the experiments in the human lab involve measuring EEG in response to sound. Sounds are generated using a Tucker-Davis (TDT) RX6 as a D/A converter. The EEG is acquired by a BioSemi system. A recording session may last 30 or 40 minutes and produce several GB of EEG data.

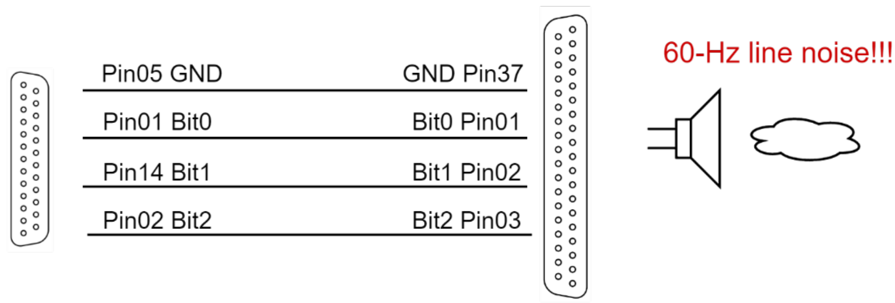
In order to analyze that data, it is necessary to know precisely when in that 30 or 40 minutes of data each of the hundreds or thousands of auditory stimuli were presented to the subject. For that purpose, the BioSemi system includes a USB interface for simultaneously acquiring digital logic pulses that are stored in a special channel along with the EEG data.

Our software that generates the auditory stimuli also generates digital pulses, precisely synchronized to the onset of each sound. These digital pulses physically come out of the DB25 Digital I/O connector on the TDT RX6. They are carried by a custom-built cable (built by me) to the 37-pin input on the BioSemi USB Interface.

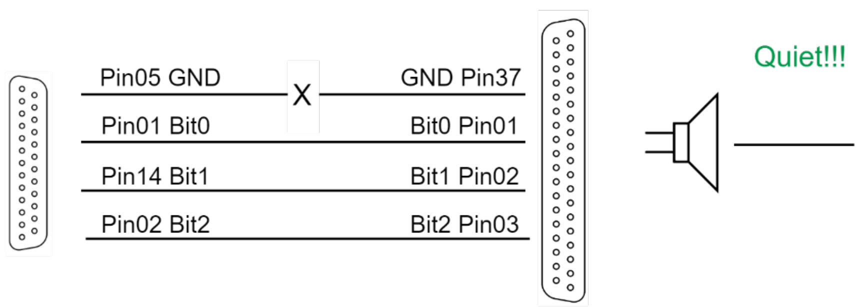


Problem

I initially wired the cable as shown below, simply connecting the three digital bits I wanted to use and the ground. We discovered, however, that connecting this trigger cable resulted in *loud* line noise on the audio inserts (especially the higher harmonics of 60 Hz). It would be impossible to run experiments with this much undesired and uncontrolled sound.

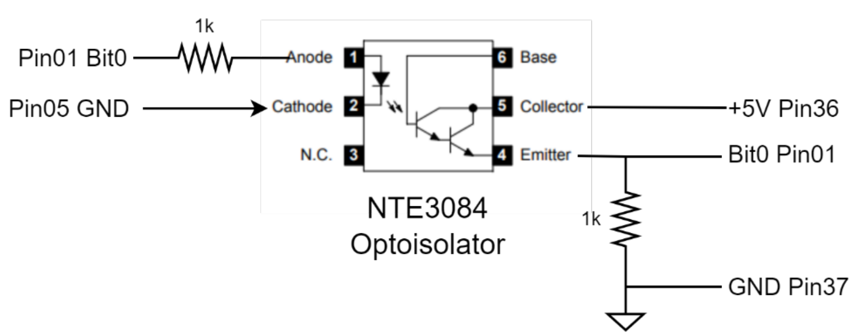


I did a bunch of troubleshooting that led nowhere, mostly to delay facing what I knew was true: line noise bleeding into a circuit like that is almost always the result of a ground loop. I confirmed this by removing the shell of the 37-pin connector at the BioSemi USB Interface and cutting the ground wire. Instant silence on the inserts. Restoring the connection also restored the noise. Definitely a ground loop.



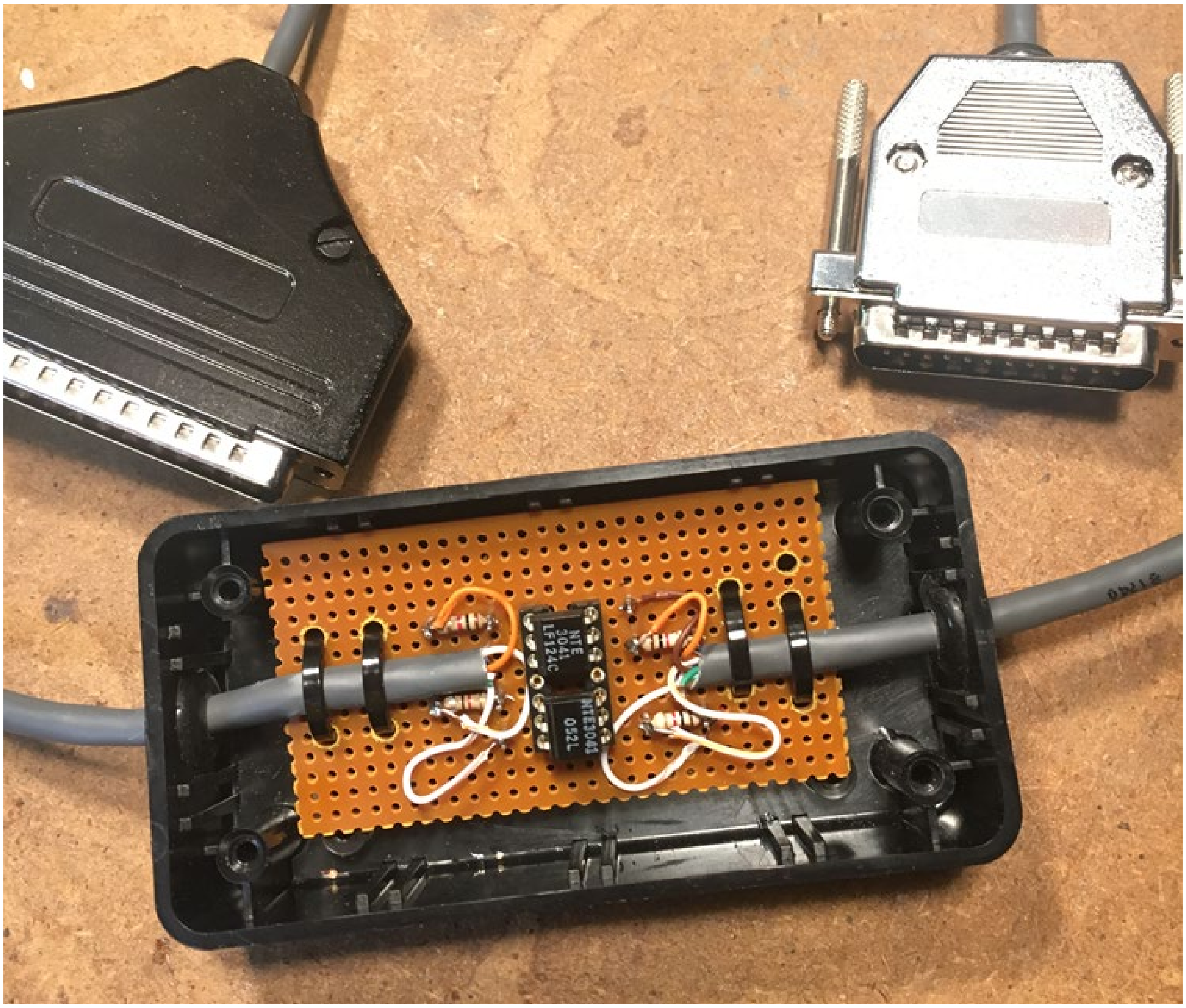
Solution

One way to solve this problem is to optically isolate the signals on the cable. Inexpensive optoisolator chips are made for this purpose. Internally, they work as follows. One digital line and ground from the TDT side are connected to an LED. When the digital line goes high, light is emitted, like any LED. The emitted light shines on a phototransistor, which effectively acts as a switch, generating a corresponding digital pulse on the BioSemi side of the cable. The pulse is thus transmitted from one side to the other,



but without any physical connection between the two halves of the circuit, avoiding the ground loop problem. Conveniently, the BioSemi USB Interface provides +5V on the cable, almost as if they knew.

Experiments were ready to start and there wasn't much time, so I did what I could as fast as I could. This involved soldering connections and resistors to vector pins in a piece of perfboard and wire wrapping underneath. I connected the cables directly to the circuit, rather than putting connectors on the box, and used cable ties to provide some strain relief.



A better solution

The chief limitation of this solution is that there are only two digital lines available. This is the bare minimum required to run an experiment: one line to mark the occurrence of each auditory stimulus, as described above, and one to mark the overall beginning of the recording. The experiment control software checks early on to make sure the BioSemi system recorded the "beginning" pulse, to ensure that the data record is complete. Missing even a single stimulus marker at the beginning makes it impossible to accurately match EEG signals to specific stimuli, and the entire data set becomes worthless.

But there are instances where it is desirable to mark other aspects of the experiment. For example, we might want to mark transitions between different kinds of stimuli or mark the times when subjects make responses in an active listening situation.

A more complete solution would probably provide a full 8 bits of data. The optoisolator chips come in quad and even octal varieties. That, combined with an efficient PCB layout, might provide the full 8 bits in the same form factor as the existing solution. (Compactness being a desirable feature, given the tight quarters in which the cable lives.)

A word about the connectors: in general, I kind of think connecting the cables directly to the board as I have done is not ideal. It feels like the circuit should exist separately from the cabling. But as mentioned above, compactness is also a desirable feature, and the direct connection helps achieve that. The 37-pin connector in particular is a bit unwieldy. So I'm a bit torn, and interested in other ideas about how this might be packaged.