Redgarden's Trans-Impedance Amplifier Demo Board Description

Introduction: Redgarden is pleased to announce the availability of its trans-impedance amplifier (TIA) demonstration board (possibly the world's first such board)! This TIA board can be used to convert the current from a photodiode to a voltage output with filtering and gain. The board has four separate channels (for four separate photodiodes) that can be assembled as needed for a variety of gains, bandwidths, and circuit topologies. The board is designed for very low-noise operation.

Unless otherwise agreed with Redgarden, the board is sold without components assembled. This lowers the price of the board and allows the user to more easily customize it for their application. For example, the desired gain of a TIA may vary from < 1kΩ to > 20MΩ! However, schematics and a bill of materials are provided with the board (for nominal component values in electronic form). All of the board components can be hand-soldered by someone with reasonable soldering skills (although some care and magnification may be needed).

Description: Please see the block diagram shown in *Figure 1* below.

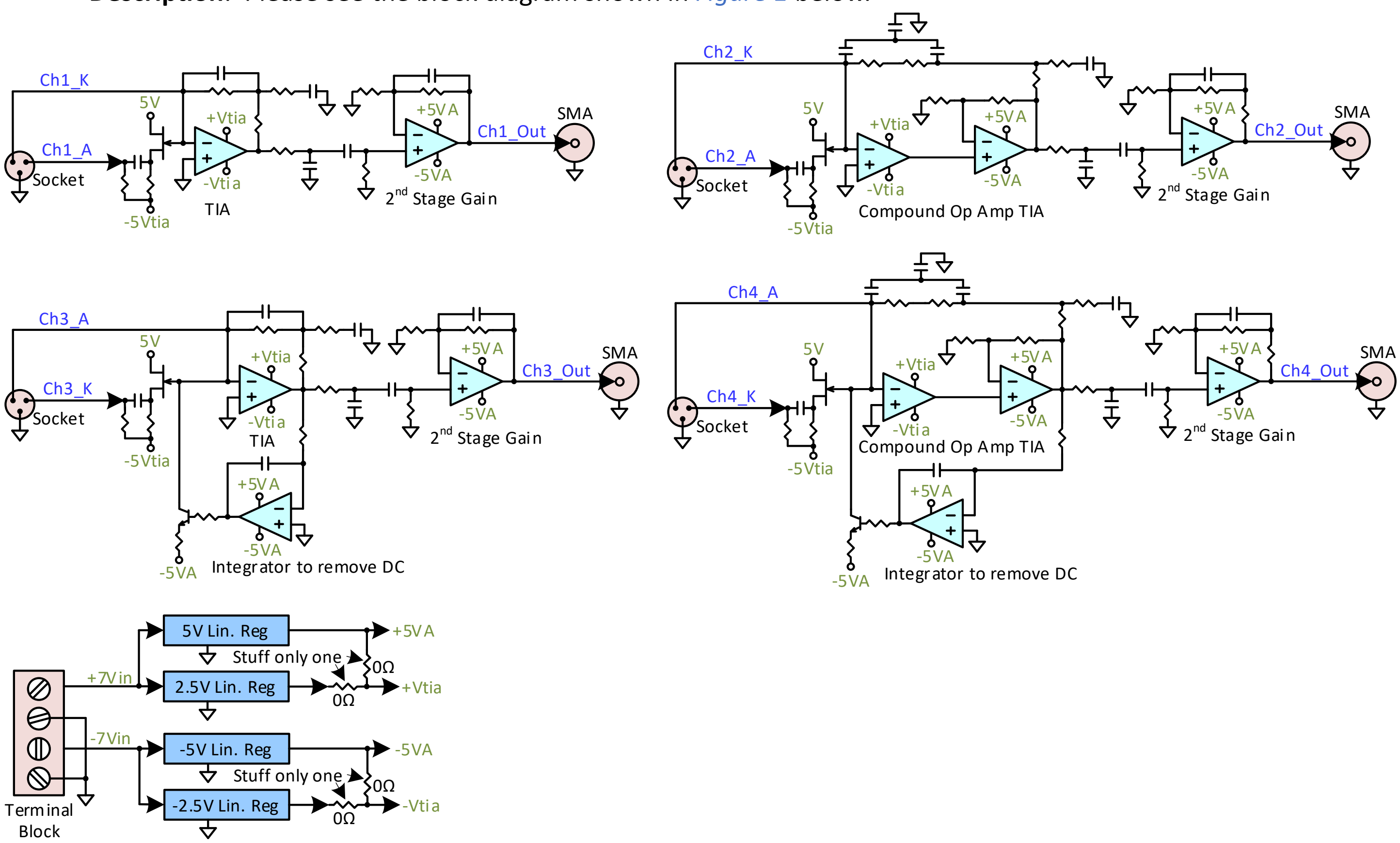

Figure 1: Block diagram for TIA Demo Board

1. Physical: The board is 5 x 3.4 inches and is approximately 0.062 inches thick. It has six mounting holes that have a 0.097-inch diameter (suitable for 2-56 screws). The board has six layers including two internal ground planes on layers two and five and power planes on layers three and four.

2. Power: The board requires +/-7V in from a bench power supply to run. Linear regulators on the board convert this to +/-5V and +/-2.5V. (The linear regulator outputs should be very quiet.) The reason for the +/-2.5V option for the TIA stage is to allow for use of op amps only rated for use at just above 5V (e.g., 5.5V max). The +/-2.5V linear regulators don't need to be stuffed if the TIA op amps will operate from +/-5V.

3. Photodiode Sockets: Each channel has its own socket for a photodiode (or the photodiode can be connected to the board with a twisted pair of wires soldered into the socket holes).

4. Output Connectors: Each channel has its output going to its own SMA coaxial connector.

5. Bootstrap JFET: Each channel includes a bootstrap JFET that can effectively drive out most of the capacitance of a photodiode (down to around 20pF). See Tech-Brief-Bootstrap-TIA-for-Large-PD-Capac-1.pdf (redgardenengineering.com). The reason to drive out high photodiode capacitance is to reduce the noise gain of the TIA (and thereby lower the noise). It is possible to bypass this JFET.

6. Bandwidth extension circuit: Each channel also includes an optional bandwidth extension circuit. See section three of Tech-Brief-Overcoming-TIA-BW-Limits.pdf (redgardenengineering.com).

7. AC Coupling Capacitors: The block diagram shows AC coupling capacitors to connect the photodiode to the TIA and to connect the second gain stage to the output of the TIA stage. Zero-ohm resistors (or resistors with other values as makes sense) may be stuffed in lieu of these capacitors to allow for DC coupling.

8. Integrators to remove DC: Channels three and four include integrators to remove the DC current in the photodiodes. These are useful if you're only interested in the AC portion of the signal. If the DC component (or very slowly changing component) is removed from the signal, more gain can be added to the TIA (since the TIA is then not also amplifying the DC portion of the signal). The integrators (and output transistors) can remain unstuffed if this feature is not needed.

9. Capacitor Tee circuits: Channels two and four include capacitor Tees that allow more precision when low-valued capacitors are needed (e.g., less than 5pF). Please see section two of Tech-Brief-Controlling-TIA-Feedback-Caps.pdf (redgardenengineering.com). Note that the circuit in section three of this same tech brief can also be stuffed using the same component footprints as for the capacitor Tee.

10. Compound op amp circuits: Channels two and four include two op amps in series for the TIA ("compound" op amps). This allows one to substantially increase the gain-bandwidth product over using a single op amp for the TIA. The first op amp should have a very low input bias current (typically in pA) while the second op amp doesn't have this requirement. The downside is that one has to account for the noise referred (referred to the input) of both op amps. The noise from the front-end op amp output is gained up by the next op amp. Also, since the overall feedback goes around both op amps, there could be stability issues if one is not careful.

11. Second stage gain: The second stage gain circuit allows the user to add further gain as needed to the TIA circuit. It also allows for one pole of high-pass filtering on the input and one pole of low-pass

filtering in the feedback. The high pass filter can be transformed into a second low-pass filter by reversing the stuffing of the resistor and capacitor, or eliminated by just putting a zero-ohm resistor in place of the capacitor.

12. Standoffs: Use of metal or plastic standoffs (e.g., 1/2-inch) with the six mounting holes on the board is recommended to avoid having the capacitance of an ESD mat coupling into the TIA circuit (which can cause stability issues. Again, use standoffs compatible with 2-56 screws or smaller.

13. Assembly and handling: TIAs with high gain are susceptible to conductive fluids on the board such as the flux from soldering or the oils from skin. Please carefully clean any flux off the board after assembling the board particularly around the TIA op amp and feedback components. Also, please use standard electrostatic discharge (ESD) prevention procedures (such as wearing a ground strap and using an ESD-prevention mat) when handling the board during and after assembly.

14. Simulating the circuitry: We recommend using LTspice for simulating op amp circuits implemented with the TIA demo board (LTspice Information Center | Analog Devices). And, of course, remember that such simulations have limitations and might not completely agree with your experimental results!

15. Consulting Assistance: Redgarden Engineering can provide consulting services to customize, assemble, and/or test the circuitry for your needs. See: Contact Redgarden - Redgarden Engineering LLC.