Specification
Transimpedance Amplifier Product
Engineering Review Draft

Document No. 1

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Revision: 0.41 (Follow-up, after Gemini Edits)

Signatures:

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Project Manager

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Engineering Manager

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Project Engineer

Section 1.0
Revision History

Date	Change Prepared by	Description of change
3/5/2026	Carl Angotti	Initial Document, for revised Device
6/17/2026	Carl Angotti	Updated Initial Document, via Gemini, Rev 0.2
6/24/2026	Carl Angotti	Updated Gemini-based Doc, Rev 0.3
6/25/2026 7/9/2026	Carl Angotti Carl Angotti	Update after Claude update, Rev 0.4 More efforts after more Claude Updates, Rev. 0.41

Section 2.0 Table of Contents

Not Applicable

Section 3.0 List of Reference Documents

Not Applicable

Section 4.0 Product Definition

This document defines a hardware product to be developed for the low-input-current-to-voltage (Transimpedance) amplifier (TIA) market. The product is a board-level, multi-range TIA module intended for interfacing photodiodes and other low-current sensors with digital voltmeters, oscilloscopes, and microcontrollers with analog inputs.
The module provides multiple selectable transimpedance gain ranges, enabling users to match sensitivity and dynamic range to sensor currents spanning from very low (picoamp-class) to higher (microamp-class) levels.

a. This multi-range capability supports both testing of photo-optical systems and integration into embedded sensing applications.

b. This device is designed as a general-purpose, high-stability front-end suitable for use by engineers and researchers and for integration into embedded prototypes and non-medical, non-safety-critical systems.

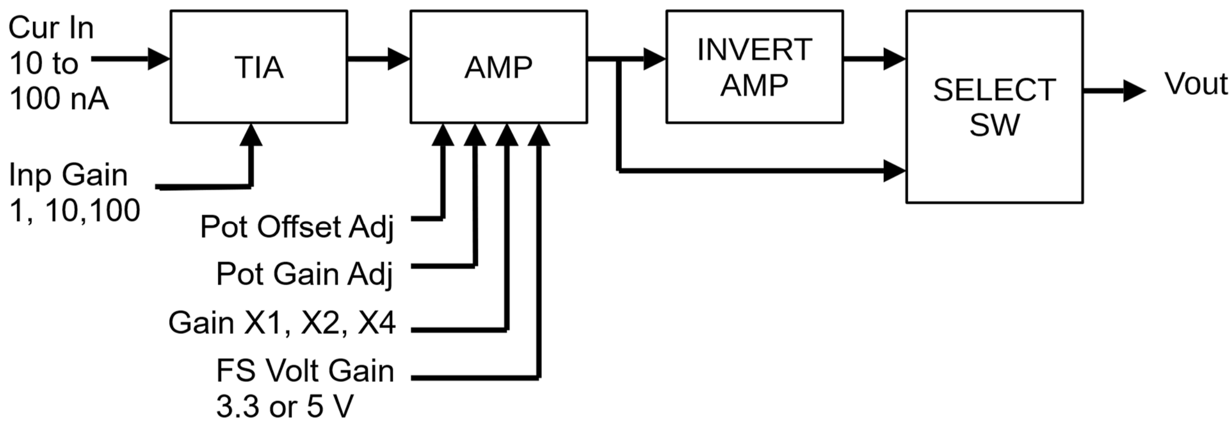
c. TIA devices of this type are commonly used in proximity detection, robotics, and general low-current sensor interfaces.

A use case example would be a 1 nA –1 µA photodiode in a light-measurement setup, connected to a 12-bit MCU ADC operating at 3.3 V.

Section 5.0

General Description of the Function of the System

The functional System for the simplest version of the Transimpedance Design is shown below. The TIA input is transformed into a voltage that passes through a multiple-gain amplifier, into a Gain-of-1 Inverting Amplifier, and through an output selection switch. The selection switch allows the signal to be inverted to accommodate different photodiode and low-level current configurations.



Block Diagram 1 – Simplest Version of the TIA circuit.

Gain Range: The TIA offers input gain selections of 1×, 10×, or 100×, with a full-scale output of 10 nA at the highest gain and 1 µA at the lowest. This is followed by a selectable X1, X2, and X4 gain via jumpers. This creates a full-scale range of 10, 20, or 40 nA at input levels of 10 nA and 250 nA at input levels of 1 uA. This configuration is equivalent to adding 2 bits of dynamic range from the input to the output of the MCU, input gain range to the standard 12-bit A/D available on most microcontrollers

Output Voltage Range: The output has a selectable full-scale range (via jumpers) of 3.3 or 5.0 volts. Hence, it will be compatible with two standard microcontroller ADCs (Analog-to-Digital Converters), such as the Arduino or Raspberry Pi.

Power Input Voltage Range: The device requires two power voltage inputs. One is positive, and one is negative, ranging from +9 Volts to +24 Volts and from -9 Volts to -24 Volts, respectively.

Section 6.0 Definition of Critical System Parameters

a. **AC or DC amplifier coupling Parameters –** This feature is switch-selected via a jumper

b. **Input Signal Range, Full Scale** (Jumper Selectable) – X1, X10, X100. This allows for a full-scale output with the inputs 0 to 10 nA, 0 to 100 nA, and 0 to 1 uA

c. **Small Step Gain Range** (Jumper Selectable) – Fixed and Adjustable - X1, X2, X4
Note: This expands the gain range by 2 bits from input to output to accommodate the maximum MCU resolution required for a signal input. Most MCUs have a 12-bit resolution on the front end.

   For example, if the output signal is not greater than ½ Scale (1.75 V at the 3.3 V output range or 2.5 V at the 5 V output range), one bit of resolution is lost. This gain change accommodates an additional 1 or 2 bits of resolution.

d. **Output Signal at Full Scale** – 3.3 or 5 V (Jumper Selectable)

e. **Absolute Accuracy** (with Adjustment) – 0.1% of full scale

f. **Zero Adjustment Rang**e - +/- 5% of full scale

g. **Gain Adjustment** - +/- 20% of Full Scale to accommodate an MCU ADC range full scale of 3.3 or 5 Volts

h. **Temperature Stability** at Full Scale and gain = < 10 uV per degree Centigrade

i. **Step Transient Response** - 10% to 90% - < 100 uSec

j. **Target Bandwidth:**

   - **Upper Bandwidth** - Minimum of 10 kHz @ -3db point

   - **Lower Bandwidth –** 0 Hz or 1 Hz, depending on whether AC or DC Coupling is selected.

k. **Output Noise Level** Peak-to-Peak – 3 mV peak-to-peak at Full Gain (10 nA input and 5 V of output. This resolves to approximately 1 bit at a 12-bit resolution and 5 Volts output

Section 7.0

Definition of User Controls and/or User Interface

This design has all manually selectable controls and two alignment potentiometers.

These selections are accomplished by jumpers installed within the circuit.

a. **Input Signal Range, Full Scale** - X1, X10, X100. Test for full-scale output with inputs of 0 to 10 nA, 0 to 100 nA, and 0 to 1 uA.
b. **Small Step Gain Range** (Jumper Selectable) – Test for Fixed and Adjustable Gain - X1, X2, X4
c. **Test for Max. Output Voltage Selection** – +3.5 or +5 volts

These selections are set via potentiometers during calibration.

1. Zero Adjust – +/- 5% of full scale
2. Gain Adjust - +/- 20% of full scale

Section 8.0

Mechanical Characteristics

This includes Size, Weight, Special Materials, etc., for hardware projects.
To be determined (TBD)

Section 9.0

Operating and Other Design Environments

This section is common in hardware projects, but could be useful for software projects that have physical deliverables for the customer.

a) Operating Temperature 25 deg C, plus or minus 10 Degrees
b) Storage Temperature - TBD
c) Shock and Vibration d) - TBD

Section 10.0

Tests Used to Define System Operation

This section defines how the unit will be tested to verify that it meets the specifications. This describes when the "deliverables" are declared completed

Functional Testing – See Functional Test Spec - TBD

Section 11. 0

Other Tests to Assure the Quality of the Design

This section can be critical for intermediate and final hardware portions of the project. Groups outside of the design group will normally perform these tests.

a) Temperature Testing – 25 Deg C, plus or minus 10 degrees
b) Compliance Testing - UL, IEC, VDE, FCC, etc - TBD
c) Reliability Analysis and/or Testing - TBD

Section 12.0 References

a) Key Component Data Sheets - TBD
b) Firmware Spec - TBD
c) Calibration Procedure - TBD
d) Schematic - TBD
e) PCB Layout – TBD