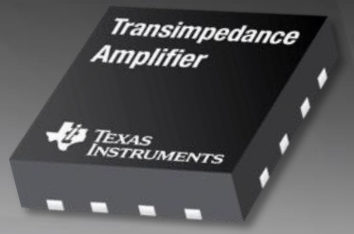
Welcome!
Texas Instruments New Product Update

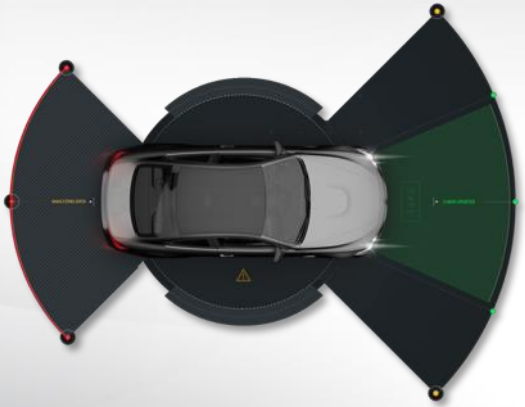
- This webinar will be recorded and available at www.ti.com/npu
- Phone lines will be muted
- Please post questions in the chat or contact your sales person or field applications engineer



New Product Update:
Transimpedance Amplifiers

Anthony Vaughan

April 29, 2021



Agenda

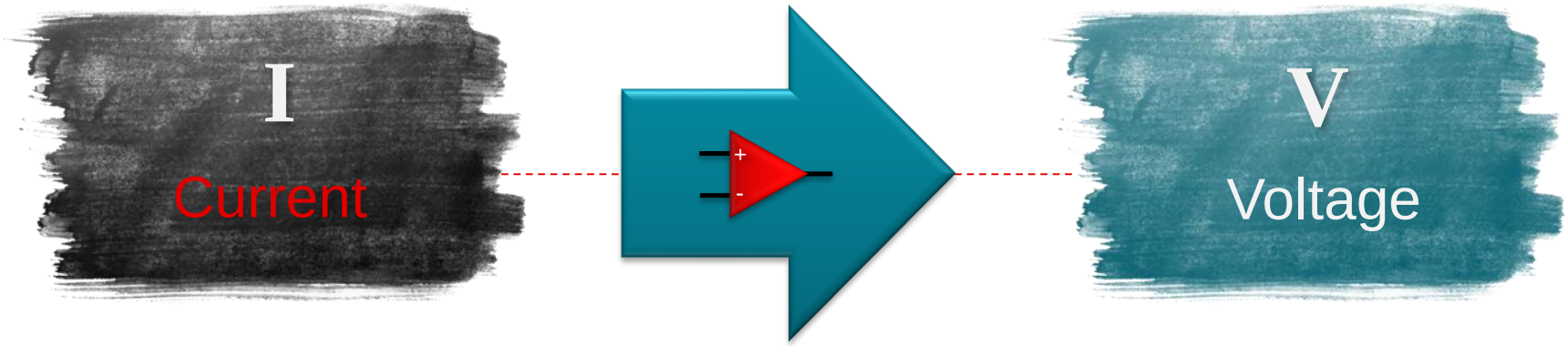
- What is a transimpedance amplifier?
- Common transimpedance applications
  - Time of Flight (ToF) & LIDAR
  - Distance measurement
  - Communications
- Discrete transimpedance amplifiers
- Integrated transimpedance amplifiers
  - Ambient light cancelation
  - Current clamp & overload protection
  - Variable gain
  - Multiple channels & multiplexing

About Me

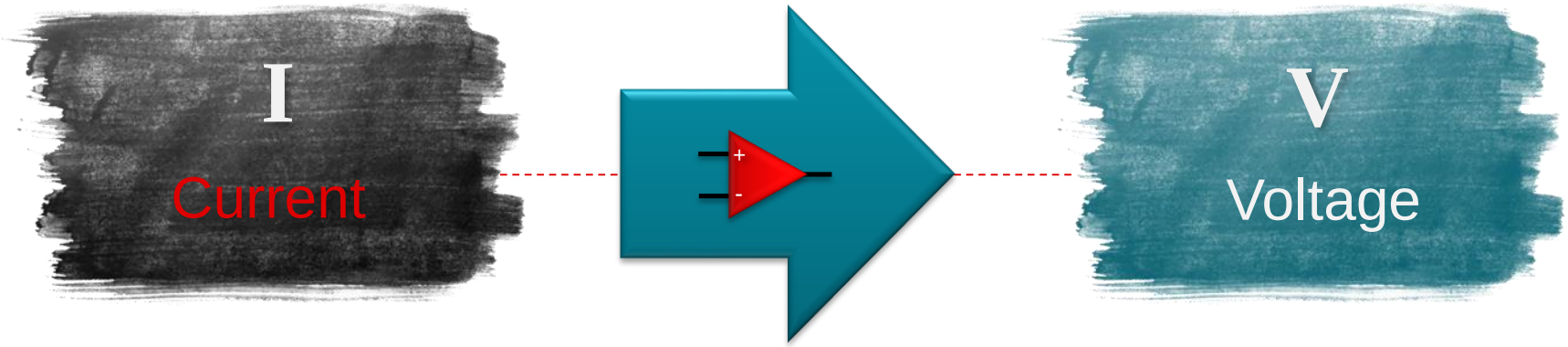
Anthony Vaughan

- High speed amplifier marketing (Tucson, AZ)
- Joined TI in 2002
  - 5 years = Marketing (high speed amplifiers – Tucson, AZ)
- TI liaison for University of Arizona Autonomous Vehicle Club
- Sponsored several senior design projects at UArizona (*LIDAR RC Car*)

What is a transimpedance amplifier?

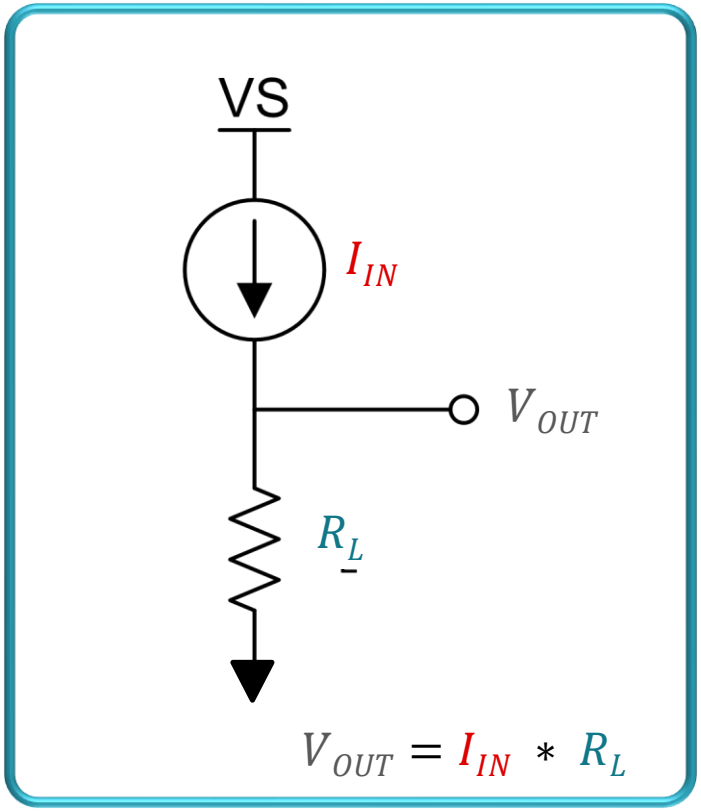


What is a transimpedance amplifier?



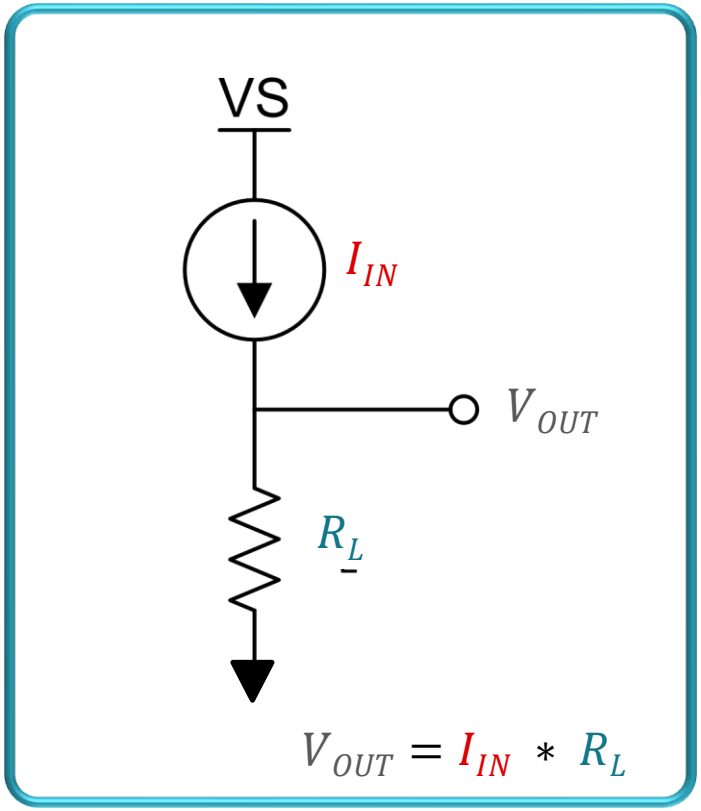
A transimpedance amplifier (TIA) is used to convert an input current to an output voltage

Basic transimpedance circuit



A basic transimpedance circuit converts a current input to a voltage output

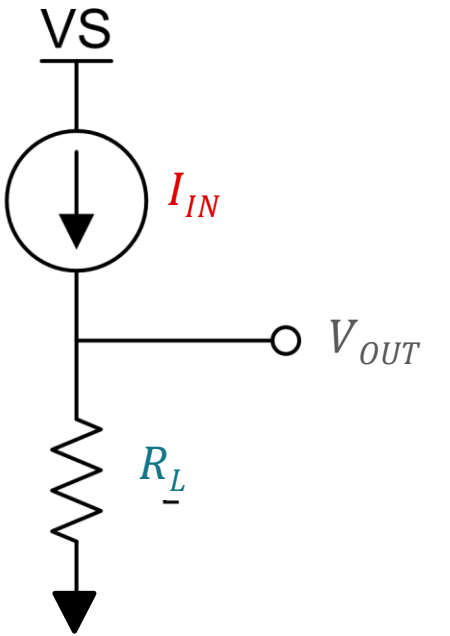
Basic transimpedance circuit



A basic transimpedance circuit converts a current input to a voltage output

The simplest form of a transimpedance circuit is a current source through a resistor

Basic transimpedance circuit

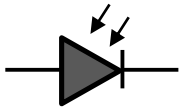


$$V_{OUT} = I_{IN} * R_L$$

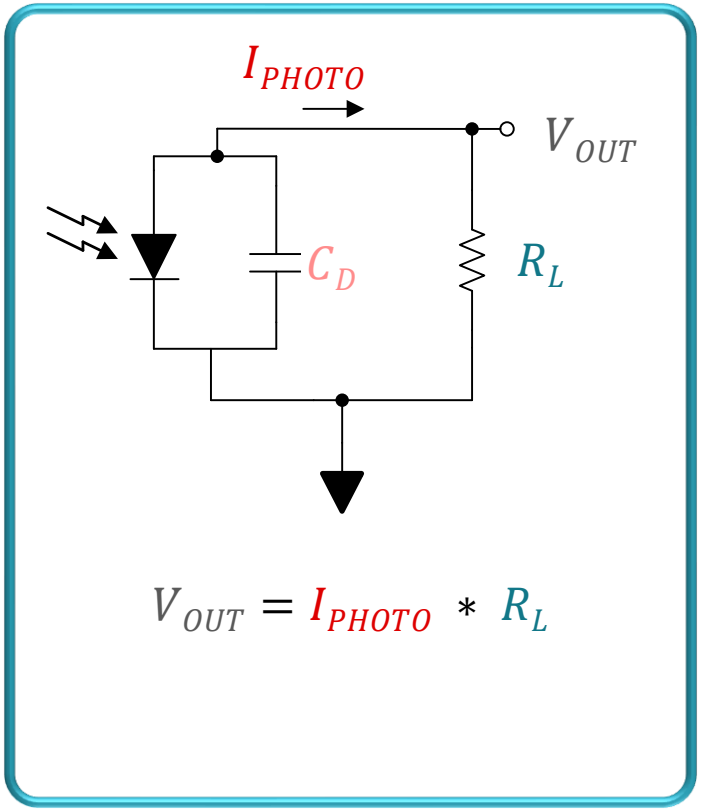
A basic transimpedance circuit converts a current input to a voltage output

The simplest form of a transimpedance circuit is a current source through a resistor

One of the most common types of current sources is a photodiode



Why not just use a resistor instead of a TIA?



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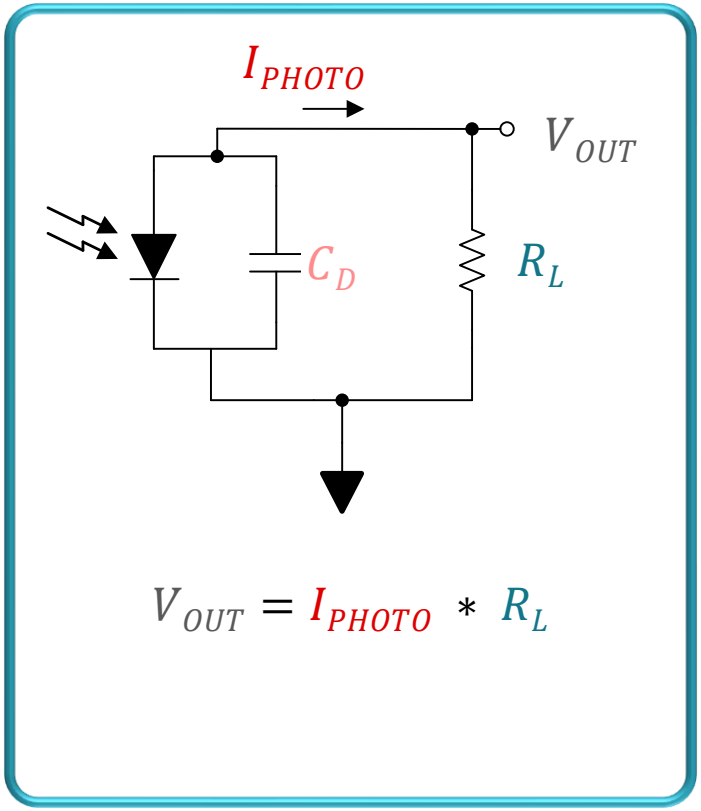

High output impedance equal to R_L

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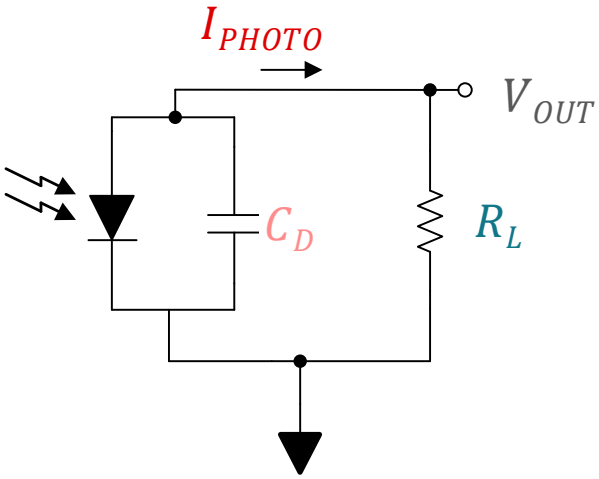
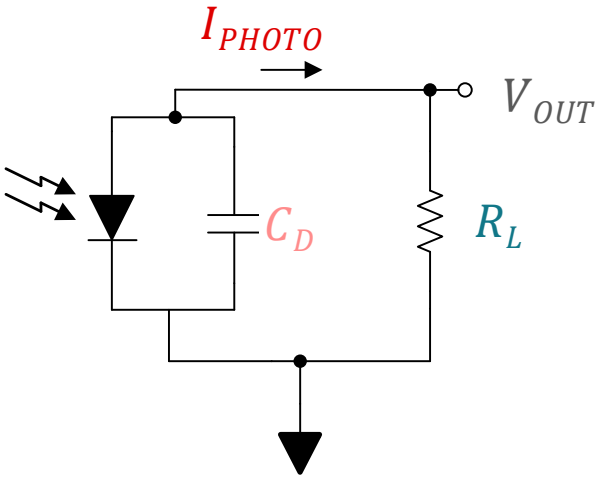


$$V_{OUT} = I_{PHOTO} * R_L$$

High output impedance equal to R_L

Output loading will effect the circuit's gain

Why not just use a resistor instead of a TIA?



$$V_{OUT} = I_{PHOTO} * R_L$$

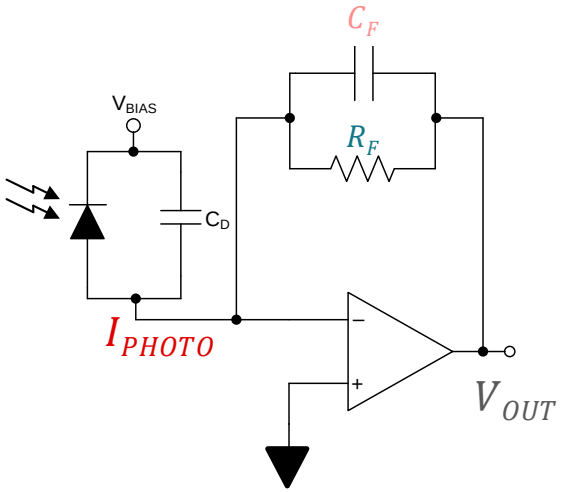
$$\tau = R_L * C_D$$

High output impedance equal to R_L

Output loading will effect the circuit's gain

Circuit time constant is determined by R_L multiplied by the input capacitance C_D

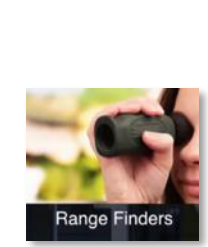
It is better to use a TIA!

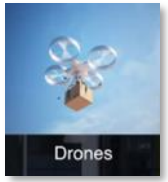


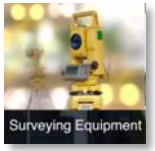
$$V_{OUT} = -I_{PHOTO} * R_F$$

Common transimpedance applications

Many products use photodiodes and require a transimpedance amplifier

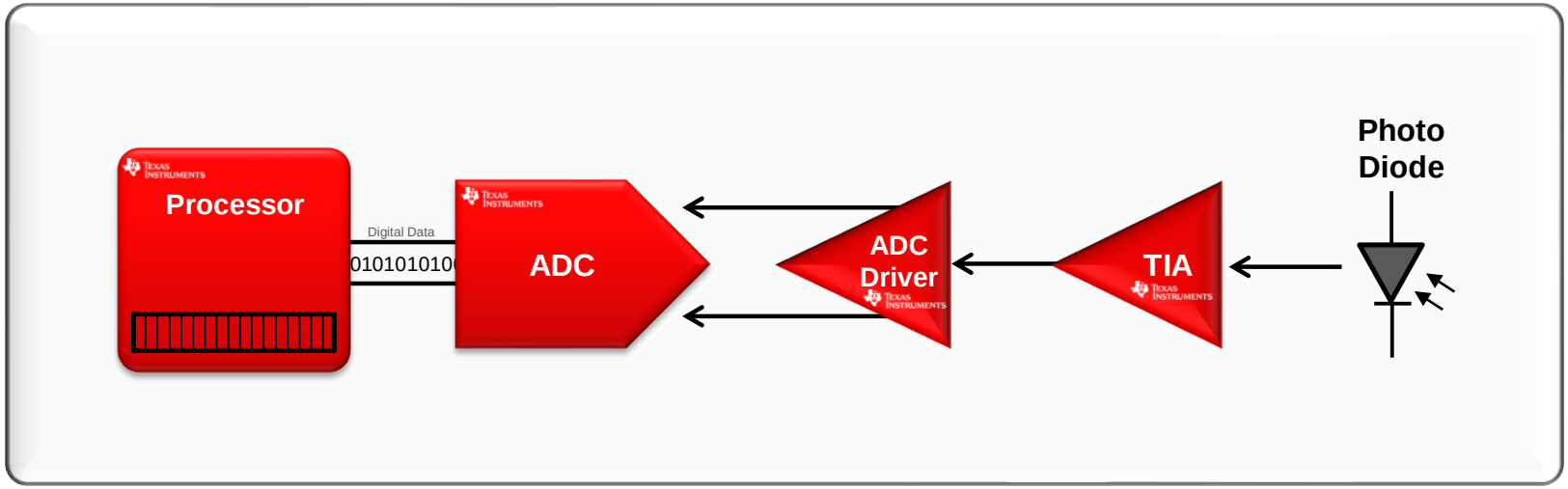






Fiber Optics

Typical transimpedance receive path



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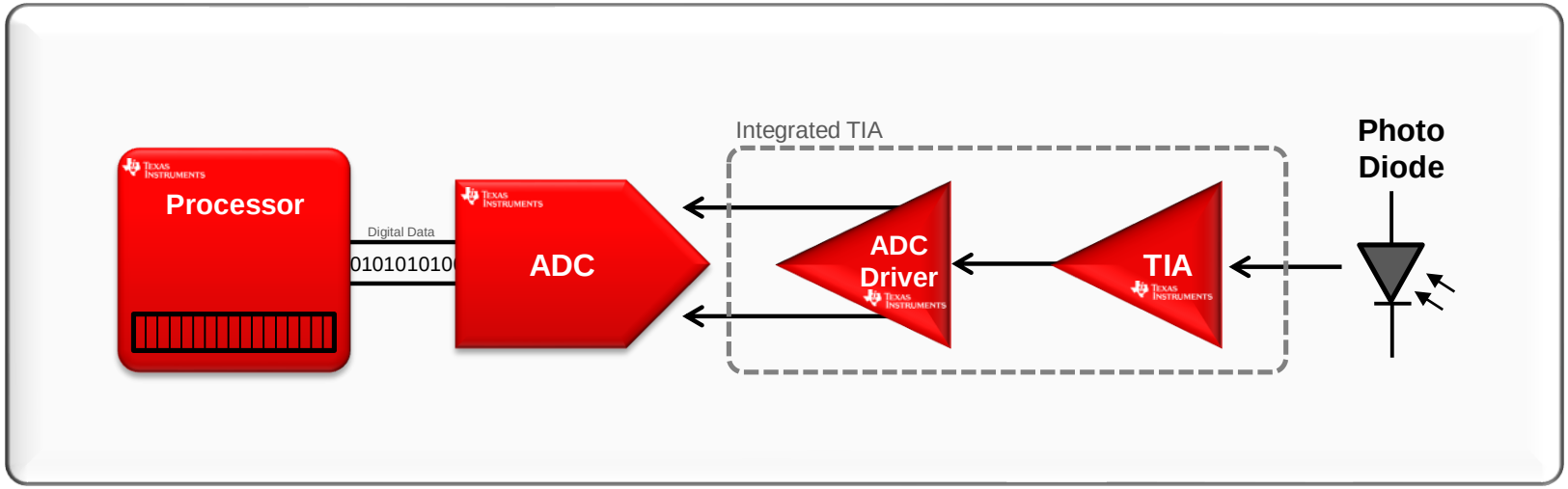


Some TI TIAs integrate a fully differential ADC driver

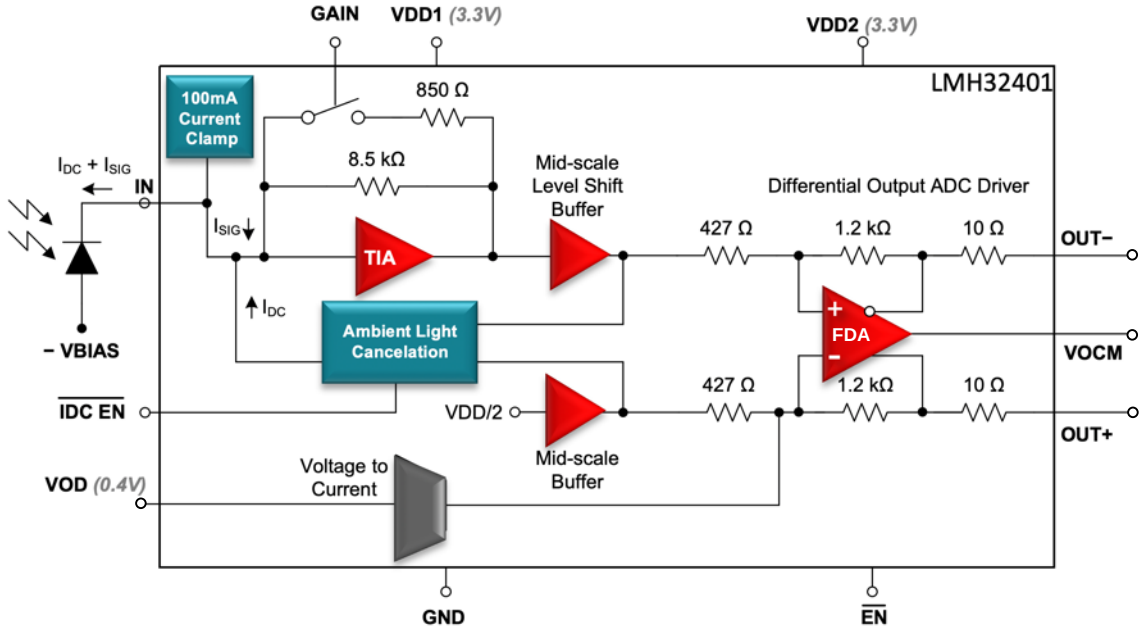
OPA85x discrete transimpedance amplifiers

Name	Input type	Gain BW	Stable gain	Applications benefit	
Q100 OPA855	Bipolar	8.0 GHz	7 V/V	Best noise at lower gains Highest bandwidth possible	Production
OPA856	Bipolar	1.2 GHz (BW)	Unity	Unity gain suitable for clamping Good noise performance for low gains	Production
OPA857	FET	130MHz closed loop @ 5kΩ 105MHz closed loop @ 20kΩ		Integrated gain settings for 5kΩ and 20kΩ transimpedance gains	Production
Q100 OPA858	FET	5.5 GHz	7 V/V	Best noise performance at high gains High bandwidth and low input current	Production
Q100 OPA859	FET	900 MHz (BW)	Unity	Maximum application flexibility Good high gain noise performance	Production

AEC Q100 automotive qualified devices

Integrated TIA LMH32401

Production

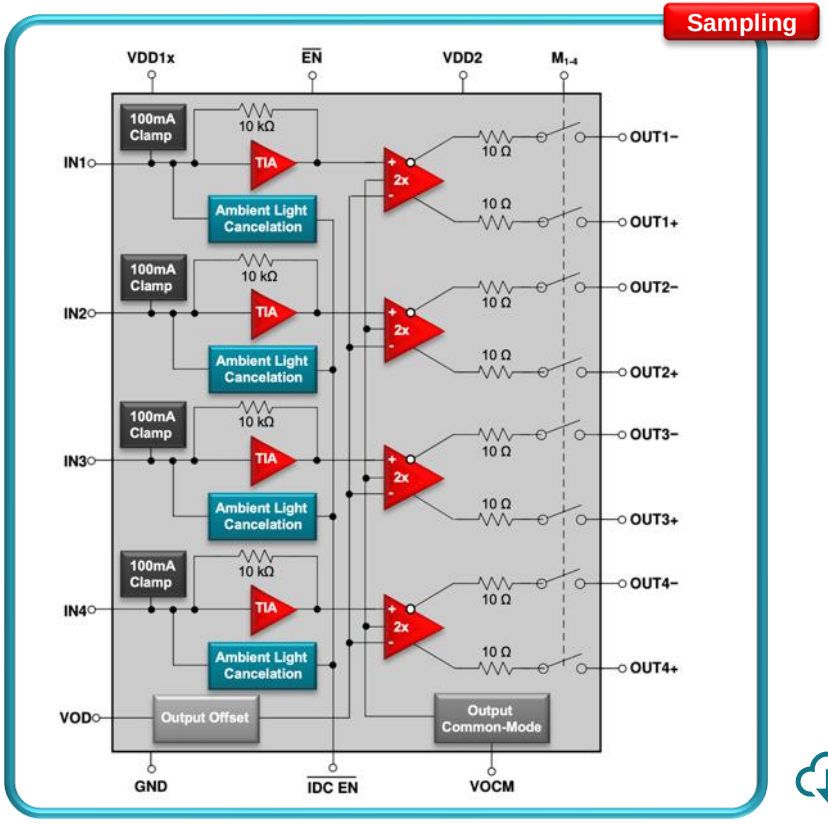


LMH32401:

- 450MHz closed loop bandwidth
- Ambient light cancelation
- Current clamp & overload protection
- Integrated programmable gain
  - 2KΩ transimpedance gain
  - 20KΩ transimpedance gain
- Integrated fully differential ADC driver
- Common mode voltage pin
- Temperature range -40˚C to +125˚C
- Small 3mm x 3mm VQFN package

www.ti.com/product/lmh32401

Integrated quad channel TIA LMH32404

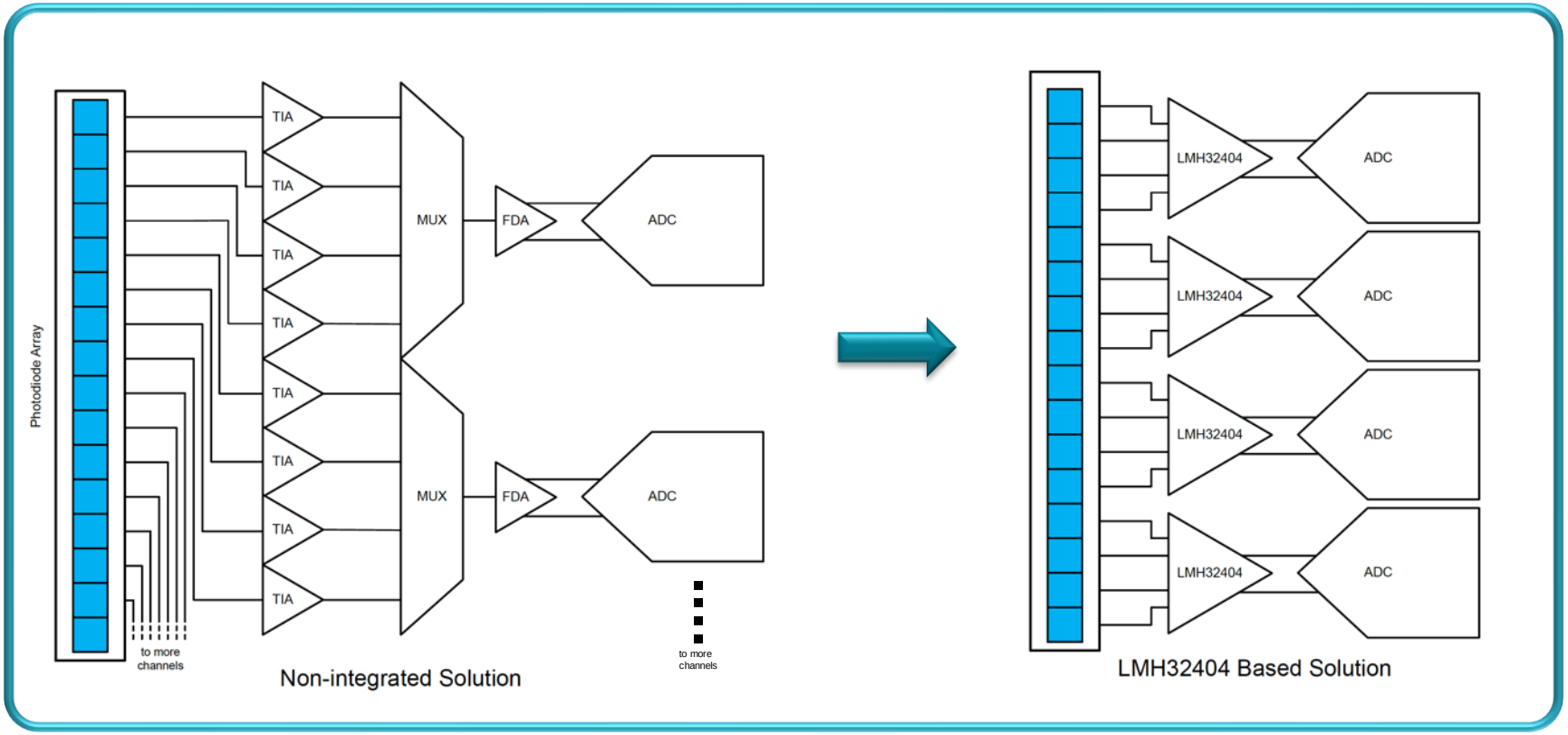


LMH32404:

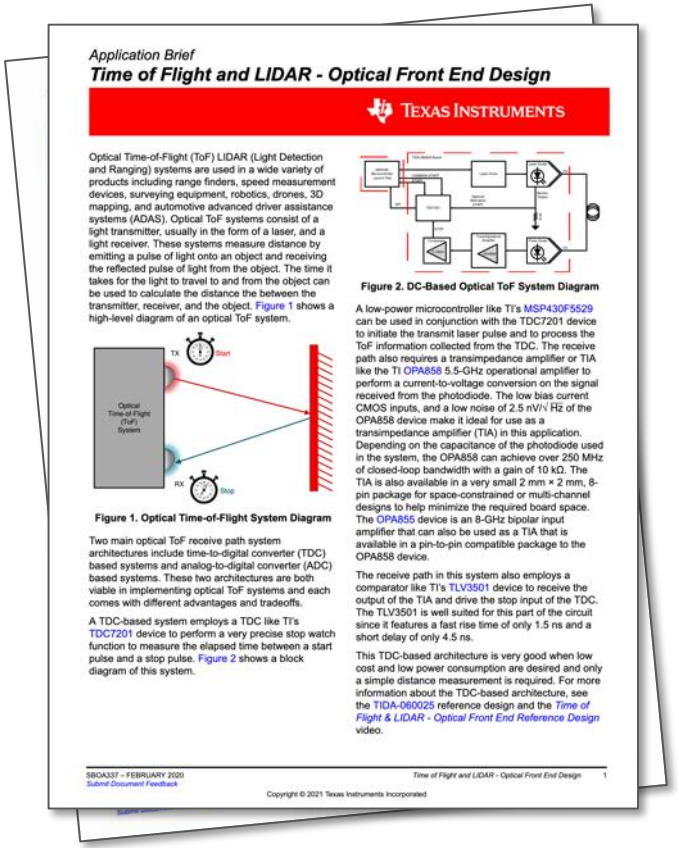
- 350MHz closed loop bandwidth
- 4 input channels & 4 differential output channels
- 10ns channel switching time
- Output switches for multiplexing
- Ambient light cancelation
- Current clamp & overload protection
- Integrated 20KΩ transimpedance gain
- Integrated fully differential ADC driver
- Common mode voltage pin
- Temperature range -40˚C to +125˚C
- Small 5mm x 4mm VQFN package

www.ti.com/product/lmh32404-Q1

Integrated quad channel TIA LMH32404



Time of Flight and LIDAR application brief



Application Brief

Time of Flight and LIDAR - Optical Front End Design

Texas Instruments

Optical Time-of-Flight (ToF) LIDAR (Light Detection and Ranging) systems are used in a wide variety of products including range finders, speed measurement devices, surveying equipment, robotics, drones, 3D mapping, and automotive advanced driver assistance systems (ADAS). Optical ToF systems consist of a light transmitter, usually in the form of a laser, and a light receiver. These systems measure distance by emitting a pulse of light onto an object and receiving the reflected pulse of light from the object. The time it takes for the light to travel to and from the object can be used to calculate the distance the between the transmitter, receiver, and the object. Figure 1 shows a high-level diagram of an optical ToF system.

Figure 1. Optical Time-of-Flight System Diagram

Two main optical ToF receive path system architectures include time-to-digital converter (TDC) based systems and analog-to-digital converter (ADC) based systems. These two architectures are both viable in implementing optical ToF systems and each comes with different advantages and tradeoffs.

A TDC-based system employs a TDC like TI's TDC7201 device to perform a very precise stop watch function to measure the elapsed time between a start pulse and a stop pulse. Figure 2 shows a block diagram of this system.

Figure 2. DC-Based Optical ToF System Diagram

A low-power microcontroller like TI's MSP430F5529 can be used in conjunction with the TDC7201 device to initiate the transmit laser pulse and to process the ToF information collected from the TDC. The receive path also requires a transimpedance amplifier or TIA like the TI OPA858 5.5-GHz operational amplifier to perform a current-to-voltage conversion on the signal received from the photodiode. The low bias current CMOS inputs, and a low noise of 2.5 nV/√Hz of the OPA858 device make it ideal for use as a transimpedance amplifier (TIA) in this application. Depending on the capacitance of the photodiode used in the system, the OPA858 can achieve over 250 MHz of closed-loop bandwidth with a gain of 10 kΩ. The TIA is also available in a very small 2 mm × 2 mm, 8-pin package for space-constrained or multi-channel designs to help minimize the required board space. The OPA855 device is an 8-GHz bipolar input amplifier that can also be used as a TIA that is available in a pin-to-pin compatible package to the OPA858 device.

The receive path in this system also employs a comparator like TI's TLV3501 device to receive the output of the TIA and drive the stop input of the TDC. The TLV3501 is well suited for this part of the circuit since it features a fast rise time of only 1.5 ns and a short delay of only 4.5 ns.

This TDC-based architecture is very good when low cost and low power consumption are desired and only a simple distance measurement is required. For more information about the TDC-based architecture, see the TIDA-060025 reference design and the *Time of Flight & LIDAR - Optical Front End Reference Design* video.

https://www.ti.com/lit/an/sboa337/sboa337.pdf

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