AIC1638

Photo Receiver Amplifier IC

RoHS COMPLIANT

FEATURES

- High Sensitivity
- Two-Wire Digital Output Interface
- Ultra-Small Footprint
- Low power
- Excellent ESD Robustness (HBM)

APPLICATIONS

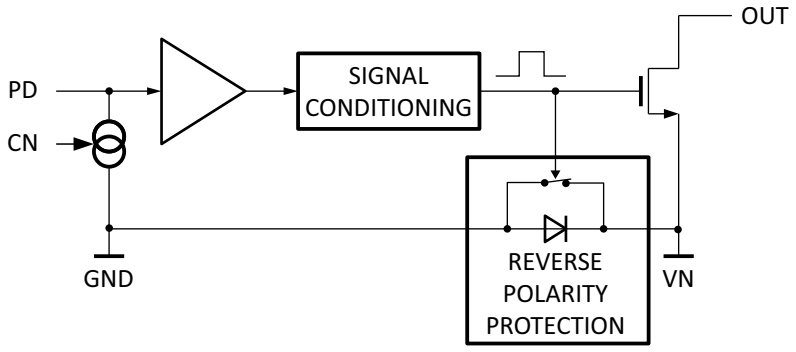
- Smoke Detectors
- Fluid Detection
- Light Barriers
- Light Curtains

DESCRIPTION

The AIC1638 is a compact, integrated receiver amplifier designed for high-sensitivity photodiodes used in applications such as light barriers, smoke detectors, light curtains, and more. By filtering out ambient light and amplifying the detected pulses from a photodiode, the conditioned signals drive a current mirror output stage. With integrated polarity protection, the device can be used in a multiplexed configuration, simplifying the wiring of the application. Optimized to reduce the need for external components, the IC can be used for light-sensing applications ranging from a few millimeters to several meters.

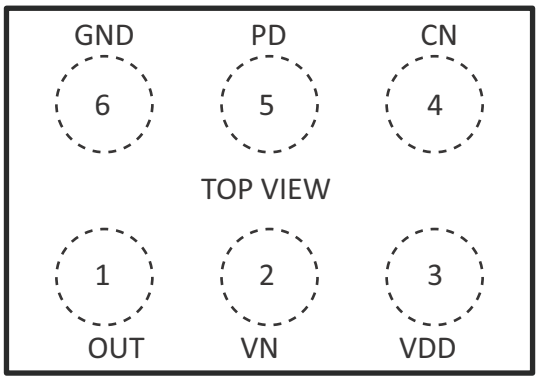
The AIC1638 has been designed to withstand ESD voltages ≥ 1kV HBM (Human Body Model) for ESD robustness. Except for the pulse input pin (PD), which meets an ESD rating of 1 kV (HBM), the other pins meet a 2 kV ESD rating (HBM).

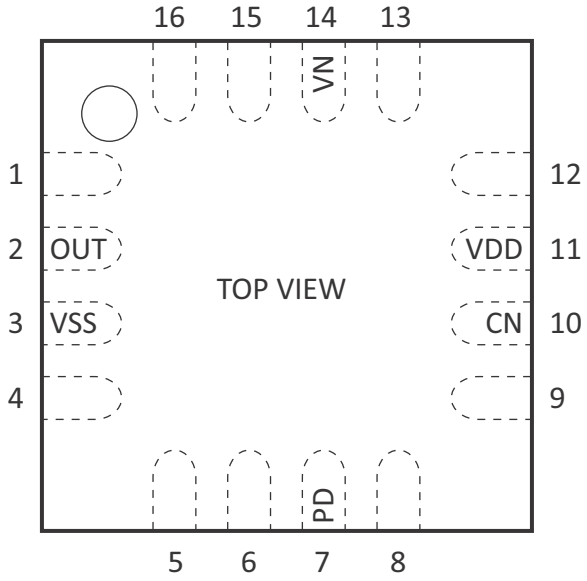
Figure 1: Block Diagram



PINOUT AND DESCRIPTION TABLE

Figure 2: AIC1638 Pinout (Top View) - CSP left, QFN right





Pin Number		Name	ESD (HBM)	Description
CSP	QFN			
1	2	OUT	2 kV	Open drain output. Signal is pulled low when a photo sensor signal is detected. Needs an external pull-up resistor to function properly.
2	14	VN	2 kV	Negative power supply (through reverse polarity protection diode)
3	11	VDD	2 kV	Positive power supply
4	10	CN	2 kV	External capacitor to filter DC inputs (i.e., ambient light)
5	7	PD	1.2 kV	Photo diode input (anode)
6	3	GND	2 kV	Ground (or negative power supply)
n/a	all others			do not connected - pins must be left floating on a PCB board

SPECIFICATIONS

Unless otherwise noted: T_A = 25°C, voltage supply V_{DD} =5.0 V.

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Min	Max	Unit
Supply voltage[1]	$\|V_{DD}\|$		5.5	V
Maximum voltage to any pin except V_{DD}	V_{IN}	-0.3	V_{DD}+0.3	V
Maximum power dissipation			300	mW
Storage temperature range (see chapter 14.2)	T_{STG}	-55	150	°C
Operating Temperature	T_A	-40	85	°C

1. AIC1638 supports polarity reversal, so the maximum supply voltage is ±5.5V

NORMAL OPERATING CHARACTERISTICS

General

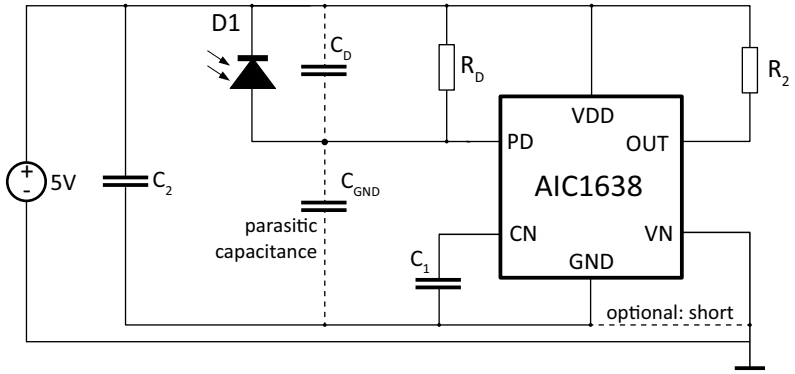
Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Power Supply Voltage	V_{DD}		4.0	5.0	5.2	V
Supply Voltage Ripple	V_{PP}	sinusoidal, 100 kHz			40	mV
Power Supply Current	I_{DD}	no signal detected		0.45	0.5	mA
Photodiode Voltage, reversed	V_{PD}			V_{DD} - 1.55		V
Photodiode Pulse, threshold	I_{PD}		60	80	100	nA
Photodiode Pulse, maximum current	$I_{PD,MAX}$				100	µA
Photodiode Capacitance	C_{PD}		15		50	pF
DC Light Current Range	$I_{PD,DC}$		0		3.0	mA
Output Current	I_{OUT}		-6.0		-10.0	mA
Power-Up Threshold Voltage	V_{SU}		3.0	3.5	4.0	V
Power-Up Threshold Voltage, hysteresis	V_{ISU}		0.5	0.75	1.0	V
Startup Time	t_{SU}	V_{DD} rise > 0.1V/µs			1.0	ms
Shutdown Time	t_{SD}				1.5	ms
Minimum light pulse repeat rate	$t_{RECEIVE}$				130	µs
Output pulse width	t_{OUT}		17	22	28	µs
Minimum photo diode pulse width	t_{PD}			6		µs
Maximum photo diode rise/fall time				500		ns
Photo diode bias resistor	R_D			27		kΩ

APPLICATION

OPERATING PRINCIPLE

A light-emitting diode (LED) emits light pulses that are received by a photodiode (D1). If there is no obstacle between the LED and D1, the light pulse generates a current pulse at pin PD of the AIC1638, proportional to the intensity of the received light pulse. If the current of the received pulse exceeds the detection threshold (I_{PD}), the AIC1638 will pull OUT low for a defined time (t_{OUT}).

Figure 3: Simple Application Circuit



REVERSE POLARITY PROTECTION

The AIC1638's reverse polarity protection allows V_{DD} to be -5V (relative to V_N). The reverse polarity protection device is implemented using a diode in parallel with a MOSFET switch. The diode is shorted by the MOSFET switch when no output pulse is generated, minimizing the voltage drop between VN and GND. During an active output pulse, the MOSFET switch is opened to prevent any interference from the decoupling capacitor C2 with the output current pulse.

An active output pulse connects the OUT pin to VN, while the internal circuit of the AIC1638 is powered by the decoupling capacitor C2. Therefore, the capacitor is necessary if polarity protection is used.

If reverse polarity protection is not required for the application, it is recommended to short VN and GND.

AMBIENT LIGHT

Continuous ambient light will generate a continuous (DC) current at the photodiode. This DC current is filtered by the AIC1638, which does not trigger a pulse at the OUT pin. However, if the intensity of the ambient light exceeds a saturation threshold ($I_{PD,DC}$), the input to the device becomes saturated, preventing it from detecting any pulses from the light-emitting diode.

PHOTO DIODE CAPACITANCE

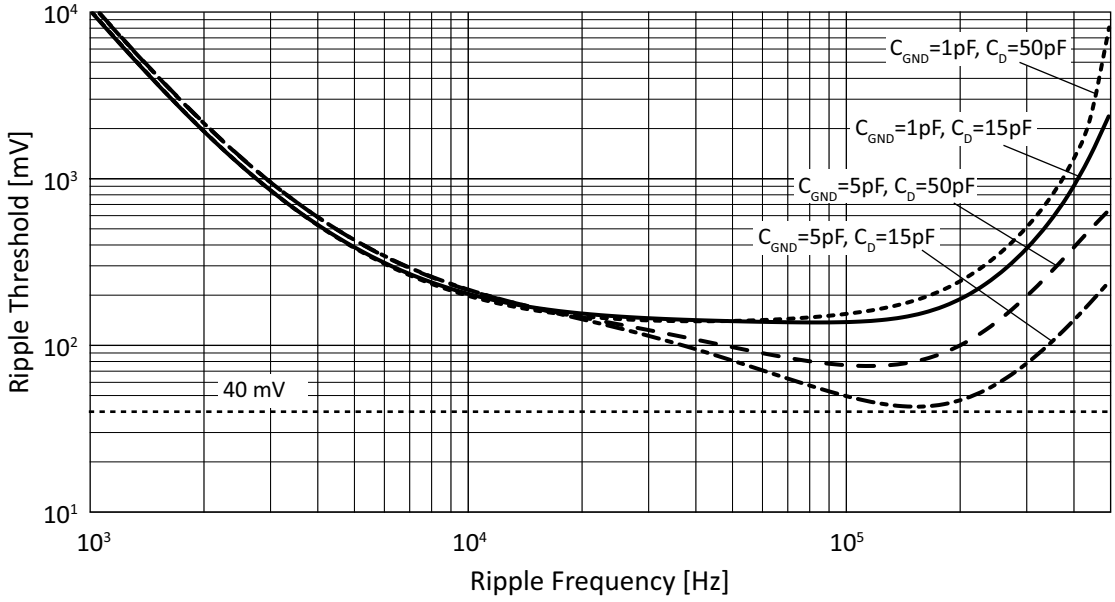
For proper operation, the capacitance of the photodiode D1 needs to be within the specified range. If the capacitance is lower than the minimum value, the system will be more sensitive to ripples in the power supply at frequencies of 200 kHz or higher. This increased sensitivity can be compensated by adding a capacitor C_D in parallel with D1, but this will also reduce the sensitivity for detecting light pulses. If the capacitance of D1 exceeds the maximum value, the sensitivity of the system will be reduced.

RIPPLE

The AIC1638 is designed to tolerate ripple voltage on the supply voltage. Figure 4 shows the threshold ripple amplitude that can cause unwanted output pulses. This threshold is frequency- and capacitance-dependent, reaching its minimum in the range of 100 kHz to 200 kHz. As the parasitic capacitance from PD to GND (C_{GND}) increases, the AIC1638 becomes more sensitive to ripple voltage. Therefore, C_{GND} should be kept as low as possible. When laying out the board, options include keeping the connections to PD as short as possible and using dedicated shielding from V_{DD}.

The ripple sensitivity can be reduced by increasing the capacitance between PD and V_{DD} (C_D) by adding a dedicated capacitor to the parasitic capacitances. However, this will negatively influence the sensitivity to the signal current pulse.

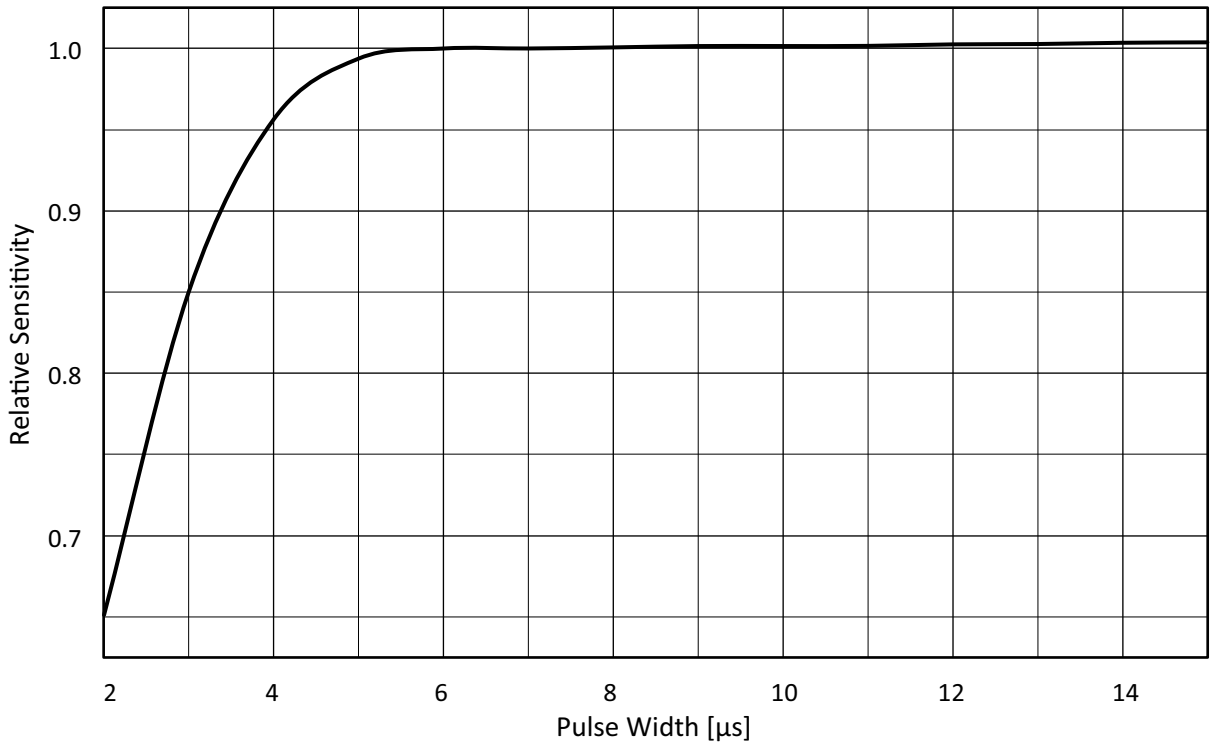
Figure 4: Voltage Ripple Threshold vs Ripple Frequency



RELATIVE SENSITIVITY

The sensitivity of the AIC1638 depends on the width of the light pulses and is reduced for short pulses. Figure 5 shows the relative sensitivity for different pulse widths, normalized against the sensitivity for a 6 µs-wide pulse. The graph is based on measurements of the required pulse current to receive 50% of the transmitted pulses.

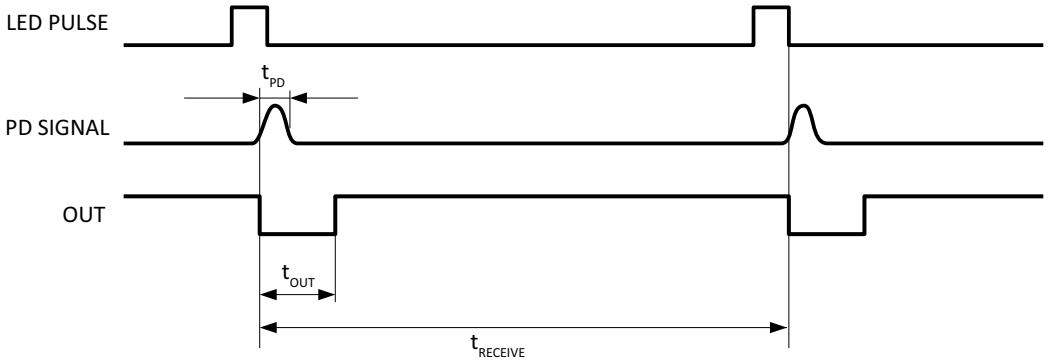
Figure 5: Relative Sensitivity vs Photo Diode Pulse Width



LED LIGHT PULSE DETECTION

When AIC1638 detects a light pulse at pin PD that exceeds the minimum photodiode pulse length (T_{PD}) and the minimum photodiode detection current (I_{PD}), it will pull the output OUT low for a defined period (T_{OUT}). The AIC1638 will then need some time to prepare for the detection of the next pulse. Thus, $t_{receive}$ defines the minimum time between two light pulses during which each pulse can be detected reliably.

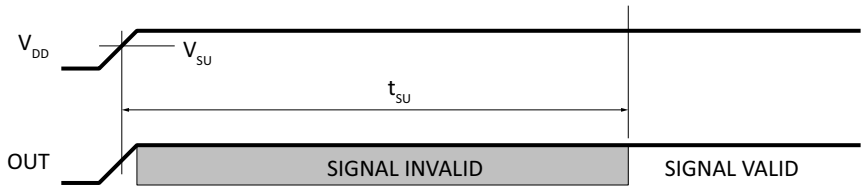
Figure 6: LED Light Pulse Detection



POWER UP SEQUENCE

Figure 7 illustrates the power-up sequence of AIC1638. Once the supply voltage VDD exceeds the startup voltage threshold V_{SU}, AIC1638 will start an internal initialization sequence. During the initialization period (t_{SU}), to output is undefined.

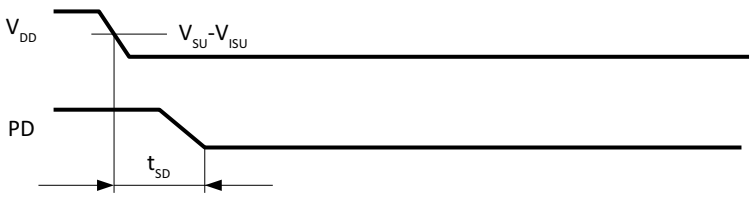
Figure 7: Power-Up Sequence



POWER DOWN SEQUENCE

AIC1638 will be turned off once the supply voltage falls below the turn-off detection threshold (V_{SU}-V_{ISU}). See Figure 8 for details.

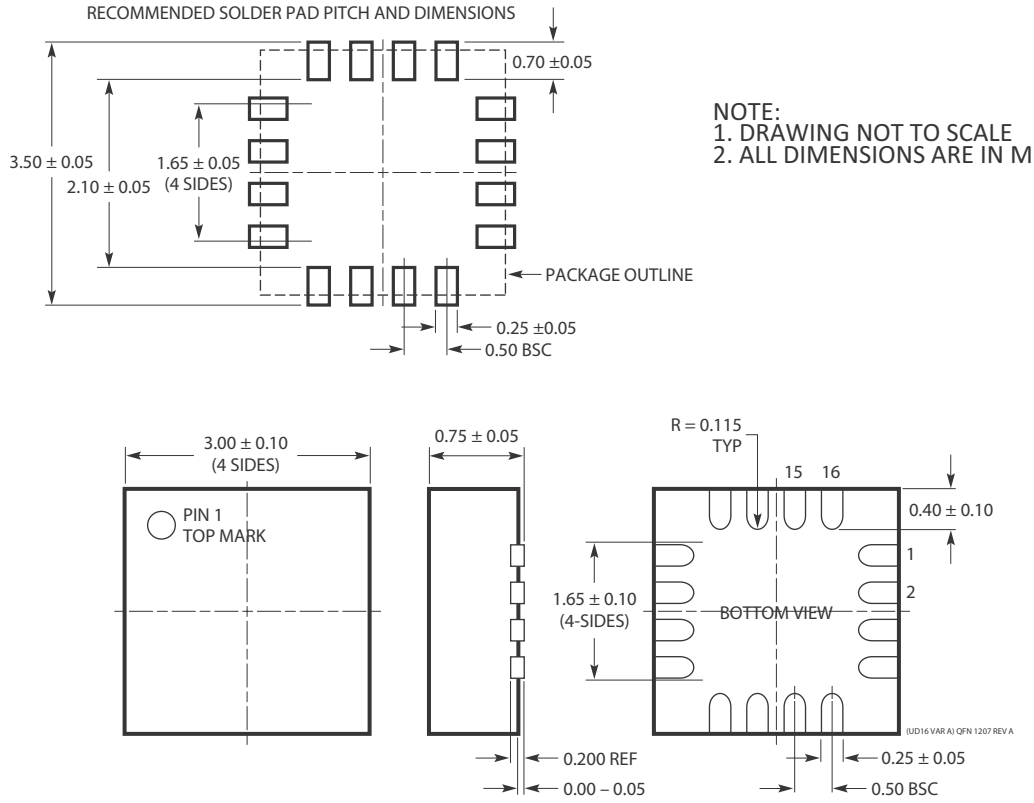
Figure 8: Power-Down Sequence



PACKAGE OPTIONS

Part Number	Apex Package Style	Description
AIC1638	ZL	16-pin QFN
		6-pin CSP

16-PIN QFN PACKAGE:



6-PIN CHIP-SCALE PACKAGE (CSP)

Please contact your local Apex representative for details and the package outline.

ESD PROTECTION

The Requirements for Handling Electrostatic Discharge Sensitive Devices are described in the JEDEC standard JESD625-A. Please note the following recommendations:

- When handling the device, operators must be grounded by wearing a for the purpose designed grounded wrist strap with at least 1MΩ resistance and direct skin contact.
- Operators must at all times wear ESD protective shoes or the area should be surrounded by for ESD protection intended floor mats.
- Opening of the protective ESD package that the device is delivered in must only occur at a properly equipped ESD workbench. The tape with which the package is held together must be cut with a sharp cutting tool, never pulled or ripped off.
- Any unnecessary contact with the device or any unprotected conductive points should be avoided.
- Work only with qualified and grounded tools, measuring equipment, casing and workbenches.
- Outside properly protected ESD-areas the device or any electronic assembly that it may be part of should always be transported in EGB/ESD shielded packaging.

STORAGE CONDITIONS

The AIC1638, 16-pin QFN package, meets moisture sensitivity classification MSL2, according to JEDEC standard J-STD-020, and should be handled and stored according to J-STD-033.