

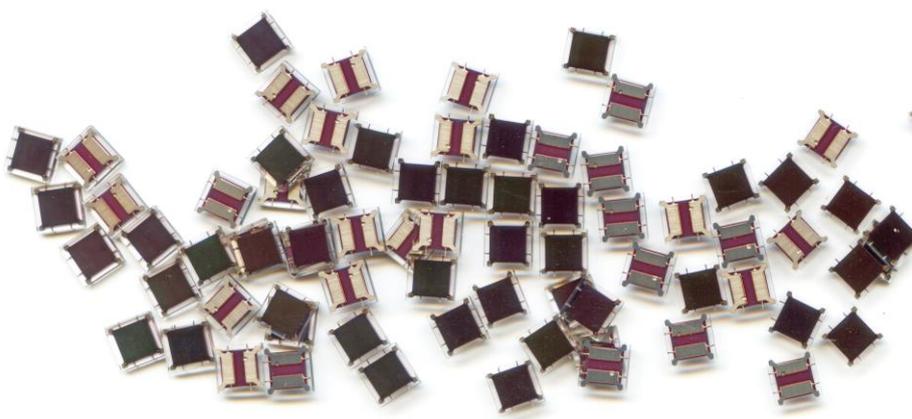
# Silicon Photomultiplier User Manual

For JOINBON TN Series

## Introduce of TN Series SiPM

TN series Silicon Photomultiplier is designed for the challenge of the detection of ultra-low flux light, the innovative design combined with advanced manufacturing process brings TN series SiPMs excellent performance such as outstanding time resolution, high photon detection efficiency, and low dark count rate, TN series SiPM possesses excellent magnetic compatibility and compact geometry benefit from its solid-state base. It's packaged in ODFN which achieves chip-scale-package (CSP) and dramatically decrease the dead-space, make it very easy to assemble them into array.

All the feature make TN series SiPMs especially advantageous for large-volume applications such as positron emission tomography(PET), security inspection machine, high energy physics experiments, also a good choice for fluorescence analysis, high energy physics experiment, flow cytometer, etc.



## Principle

The Silicon Photomultiplier is a novel silicon-based photodetector, which presents the modern perspective of low photon flux detection. It consists of an array of space-distributed micro sensors, each sensor is able to detect down to single quantum of light. The array is detecting the incoming photon flux.

The micro sensor detection structures are formed of two regions with different conductivity (p- and n-doped silicon). By applying a reverse bias to such structure, a depleted area is formed with low concentration of carriers and in-built electric field. The structure is designed specifically to match the photon detection condition via photoelectric effect within the depleted area. When the bias is larger than the breakdown voltage, the electric field will be higher than  $10^5\text{V/cm}$ . In high electric field, free carriers are accelerated and could reach the energy higher than the ionization energy of valence electrons, the consequence of the secondary impact ionization is the avalanche multiplication corresponding to the initial charge created by the interaction of the photons.

The schematic of such micro sensor is shown in Fig 1, the micro sensor consists of a pn junction and a quenching resistor. After the initiation of the avalanche breakdown process the current through the structure raises and causes a voltage drop on the resistor with consequent voltage drop on the bias applied to the pn junction of the micro sensor. The avalanche stops, when the voltage drop on the quenching resistor lowers the voltage applied to the pn junction below the breakdown voltage. After the structure is quenched, a recovery time is necessary to allow any free or stored charge to be swept from the active region of the device and to restore the excess bias across the microcell.

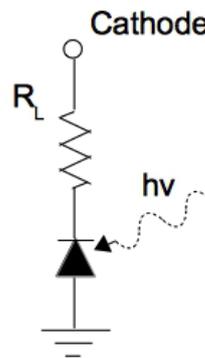


Fig. 1 Schematic of micro sensor

The SiPM is composed of a space-distributed array of such microcells as Fig 2. The output of the SiPM is the analogue sum of the signal of all microcells, connected in parallel to a common electrode structure.

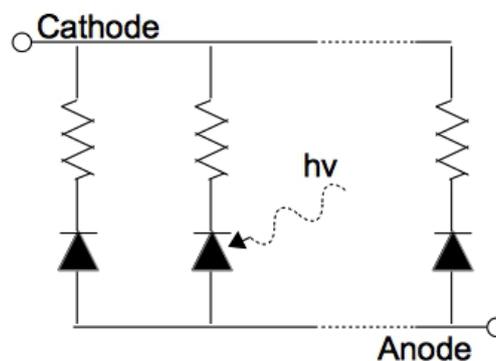


Fig.2 Schematic of SiPM

## Readout

The TN series SiPMs are easy-using production. For readout the signal of SiPM, proper positive bias voltage applied to the cathode with reference to the anode is needed. In this case, hold a positive bias at cathode and keep anode at 0V, or hold a negative bias at anode and keep cathode at 0V are alternative. For the bias supply, the following configuration in Fig.3 is recommended. The RC filter will reduce the influence of the voltage supply on SiPM.

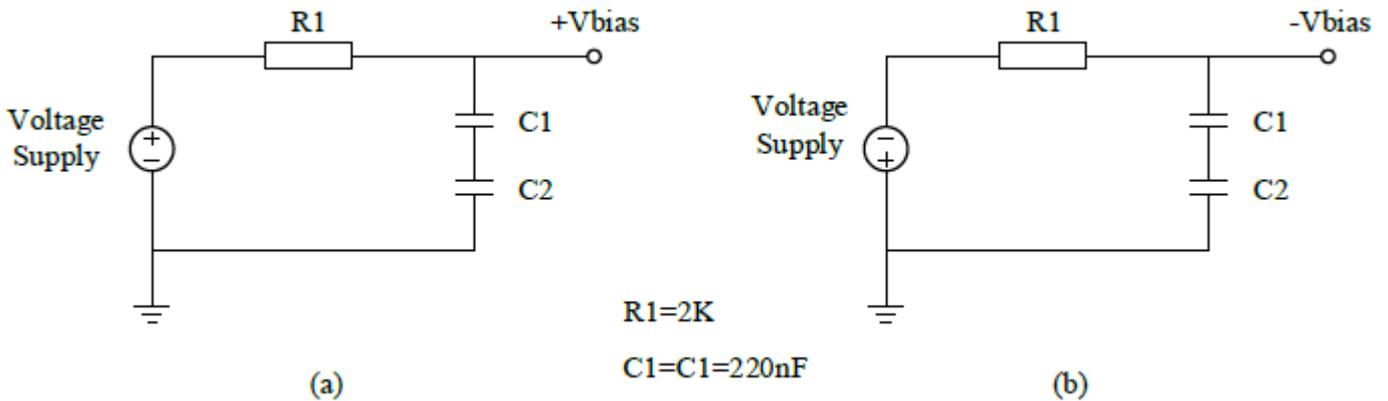


Fig.3 Configuration of bias supply, (a) positive bias and (b) negative bias

There are 4 kinds of possible ways in which the TN-series SiPM can be biased, as shown in Fig.4 below.  $R_L$  is the load resistor, its typical value is  $50\Omega$ .

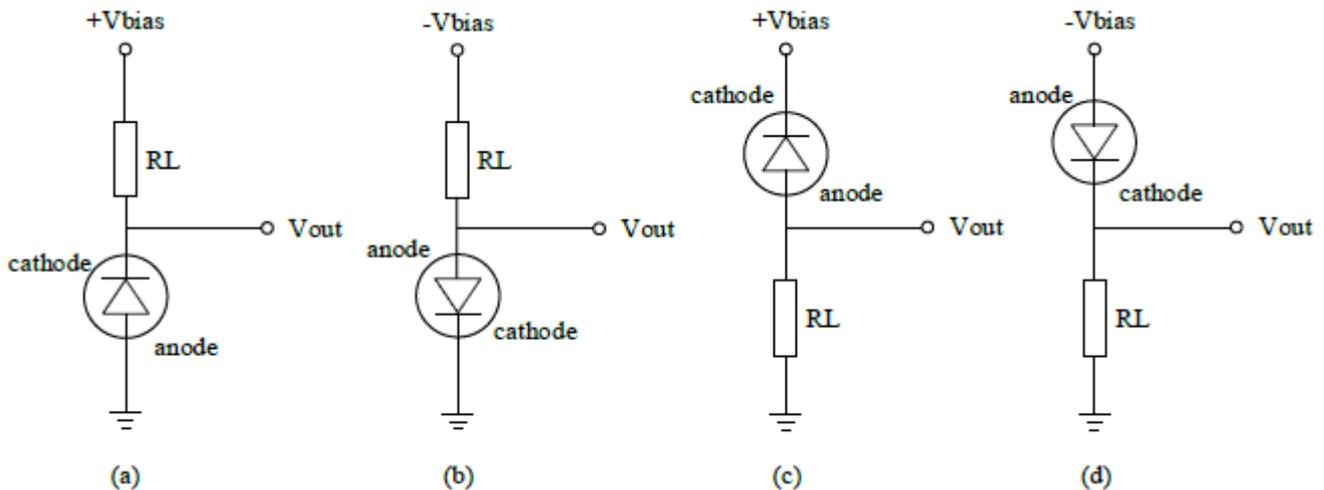


Fig.4 Biasing alternative

Normally, a capacitor is used to couple to the output. It is recommended to use the following configuration in Fig.5 for signal readout.

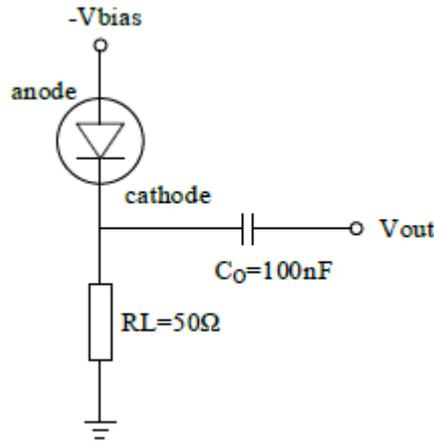


Fig.5 Recommended readout circuit for TN-series SiPM

Fig.6 shows how the TN-Series SiPMs can be connected to a standard high speed amplifier, such as the GALI-S66+, to amplify the amplitude of the output signal.

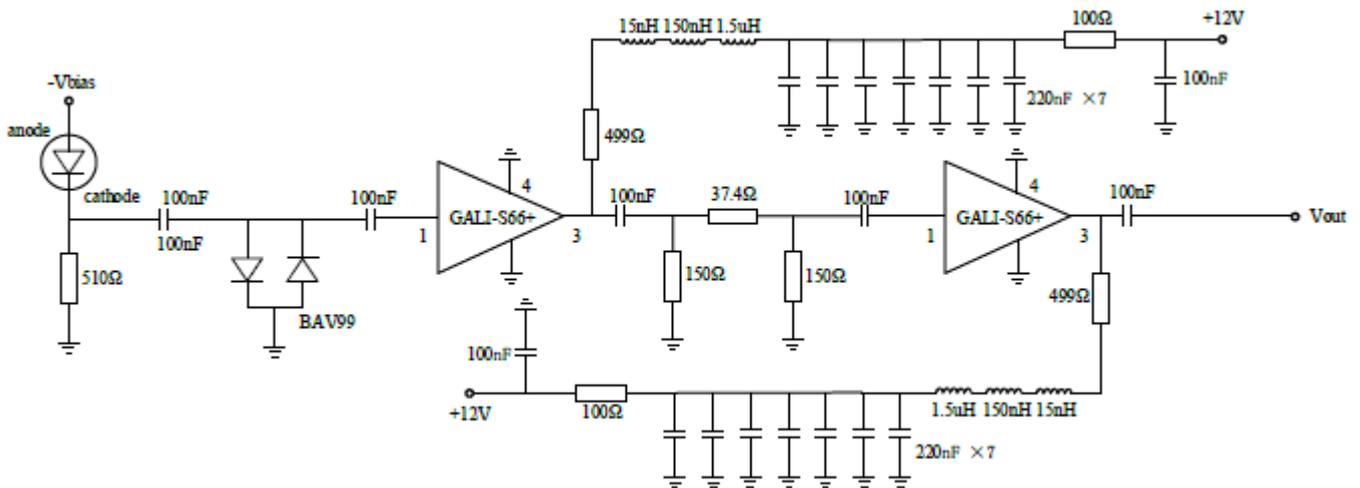


Fig.6 Recommended readout circuit with amplifier

## Handling and Soldering

The SiPM product is sensitive photoelectric detector, any kind of dirt, stress, ESD may result in the degeneration of electrical and optical performance, so always be careful during the using of SiPMs.

The SiPM product is compatible with standard reflow soldering process for high-volume production. We provide professional information about baking and reflow soldering instruction for the SiPM production.

More information about the handling, storage and soldering for JOINBON SMT products, please visit our [website](#) for more help or refer to the document “[Technical Note for SMT products](#)”.



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