US010541660B2

(12) **United States Patent**
McKisson

(10) **Patent No.:** US 10,541,660 B2
(45) **Date of Patent:** Jan. 21, 2020

(54) **PASSIVE BIAS TEMPERATURE COMPENSATION CIRCUIT MODULE**

(71) Applicant: **JEFFERSON SCIENCE ASSOCIATES, LLC**, Newport News, VA (US)

(72) Inventor: **John E. McKisson**, Williamsburg, VA (US)

(73) Assignee: **JEFFERSON SCIENCE ASSOCIATES, LLC**, Newport News, VA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 246 days.

(21) Appl. No.: **15/792,437**

(22) Filed: **Oct. 24, 2017**

(65) **Prior Publication Data**

US 2018/0115290 A1   Apr. 26, 2018

Related U.S. Application Data

(60) Provisional application No. 62/412,495, filed on Oct. 25, 2016.

(51) **Int. Cl.**
H03G 3/20   (2006.01)
H05K 1/18   (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC *H03G 3/20* (2013.01); *G01J 1/44* (2013.01); *H01C 7/008* (2013.01); *H03G 1/0041* (2013.01); *H03G 3/3084* (2013.01); *H05K 1/185* (2013.01); *H05K 3/30* (2013.01); *G01J 2001/444* (2013.01); *H03G 2201/708* (2013.01); *H05K 1/186* (2013.01); *H05K*

2201/1006 (2013.01); *H05K 2201/10015* (2013.01); *H05K 2201/10022* (2013.01); *H05K 2201/10151* (2013.01); *H05K 2201/10219* (2013.01); *H05K 2201/10515* (2013.01); *H05K 2201/10522* (2013.01)

(58) **Field of Classification Search**
CPC .. H05K 1/185; H05K 3/30; H03G 3/20; G01J 1/44; H01C 7/008
USPC .... 250/214 C
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,548,112 A   8/1996 Nakasi et al.
5,578,815 A   11/1996 Nakasi et al.
(Continued)

Primary Examiner — Kevin K Pyo

(57) **ABSTRACT**

A passive bias temperature compensation module for silicon photomultiplier, avalanche photodiodes and similar photodetectors that possess a moderately linear temperature coefficient of gain and that may be compensated by varying an applied bias voltage. The module includes an electrical circuit and a method for determining component values to provide a constant voltage source to stabilize the gain of one or more photodetector devices. A temperature sensor in the module is held in close thermal contact with the photodetector and a filter capacitor is electrically close to the photodetector. The module is based on the concept of temperature sensitive voltage division which is applicable to situations in which large numbers of photodetectors must be gain-compensated for temperature variations over a wide range while maintaining excellent gain matching. The passive bias temperature compensation method enables multiple photodetectors to share a single constant voltage supply without loss of matching performance.

10 Claims, 7 Drawing Sheets