



(19) **United States**

(12) **Patent Application Publication**  
**Ge et al.**

(10) Pub. No.: US 2022/0399899 A1

(43) **Pub. Date:** **Dec. 15, 2022**

(54) **MULTISTAGE ANALOG-TO-DIGITAL  
CONVERTERS FOR CROSSBAR-BASED  
CIRCUITS**

(52) **U.S. Cl.**  
CPC ..... *H03M 1/468* (2013.01); *H03M 1/361*  
(2013.01)

(71) Applicant: **TetraMem Inc.**, Newark, CA (US)

(72) Inventors: **Ning Ge**, Newark, CA (US); **Wenbo Yin**, Alameda, CA (US)

(21) Appl. No.: 17/347,516

(22) Filed: **Jun. 14, 2021**

## Publication Classification

(51) **Int. Cl.**  
*H03M 1/46* (2006.01)  
*H03M 1/36* (2006.01)

(57) **ABSTRACT**

In accordance with some embodiments of the present disclosure, an apparatus including a crossbar circuit is provided. The crossbar circuit may include a plurality of cross-point devices with programmable conductance, a transimpedance amplifier (TIA), and an analog-to-digital converter (ADC). The TIA is configured to produce an output voltage based on an input current corresponding to a summation of current from a first plurality of the cross-point devices. The ADC is configured to generate a digital output corresponding to a digital representation of the output voltage of the TIA. To generate the digital output, the ADC is to generate, using a comparator, a first plurality of bits (e.g., MSBs) of the digital output by performing a coarse conversion process and a second plurality of bits (e.g., LSBs) of the digital output by performing a fine conversion process on a sample-and-hold voltage produced in the coarse conversion process.

