JULY 12–16
2020 VIRTUAL
JOINT AAPM | COMP MEETING
EASTERN TIME [GMT-4]

Design and Testing of an Active Matrix Pixel, Data Acquisition and Microcontroller System for Dosimetric Measurements

D. Roa, R. Challco, Z. Arqque, O. Paucar, C. Guzman, A. Gonzales, A. Gonzales, M. Montoya, J. Hernandez

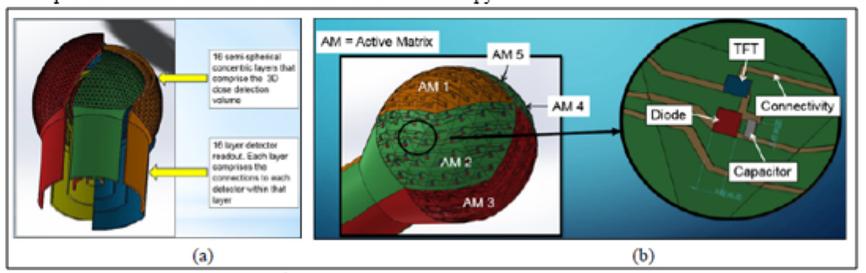
Purpose: To analyzed the linearity, dose rate dependence and percent depth dose response of an active matrix pixel, data acquisition (DAQ) and microcontroller system for radiation dose readout.

Methods: A low cost active matrix (AM) pixel, DAQ and microcontroller system were designed and constructed for dosimetric measurements. The AM pixel consisted of a BPW34S photodiode, a 1 μF storage capacitor and a NX7002AK MOSFET. The DAQ comprised an integrator, filter and amplifier while the microcontroller was a commercially available unit. A 6 MV x-ray beam irradiated the AM pixel to doses of 50, 100, 150, 200 and 250 MU for the linearity tests and, dose rates of 200, 300, 400, 500 and 600 MU/min for the dose rate tests. PDD data was collected at AM pixel depths of 1.6, 2, 10, 15 and 20 cm in water and were compared to MC simulations and linac commissioned water PDD data. Linearity and dose rate tests were performed using readout collection times of 0.25 s, 1 s and 2 s to determine the system's dependence on this parameter.

Results: Linearity and dose rate measurements showed a percent difference of ≤ 2% for collection times of 0.25-2 s. Response improved when the collection time was 0.25 s. Shorter collection times were prevented by the DAQ speed. Measured PDD data showed a maximum difference of 2.2% compared to the commissioned data and 2.4% compared to the MC data, both at 1.6 cm depth.

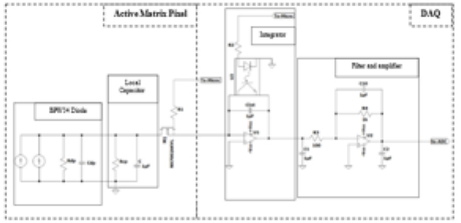
Conclusions: These results demonstrate that a radiotherapy readout system based on an active matrix design can provide accurate dosimetric data. Moreover, the dosimetric data could be further improved with a higher speed DAQ unit that can allow for a shorter (< 0.25 s) data collection time.

Innovation/Impact: This is an initial phase of a larger project (see Fig. below) consisting of an active matrix based connectivity configuration of 31,560 detector elements in a three-dimensional electronic detector array for IMRT/VMAT quality assurance. Preliminary results suggest that an active matrix connectivity design could provide reliable radiation dose readout in radiotherapy.

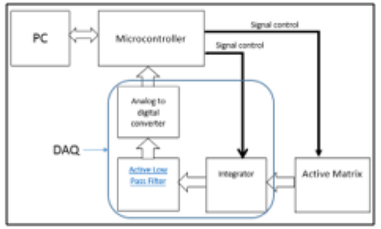


(a) Diode detectors of 0.5 x 0.5 x 0.3 mm^3 are imbedded within the 16 semi-spherical layers. (b) An active matrix (AM) configuration provides connectivity to each detector. An AM pixel consists of a diode, capacity and TFT and each diode is located at the center of a triangle.

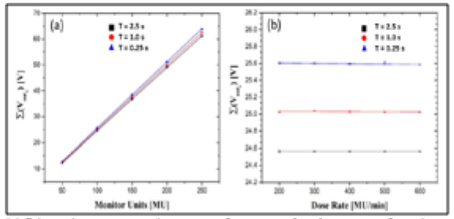
System Description and Results:



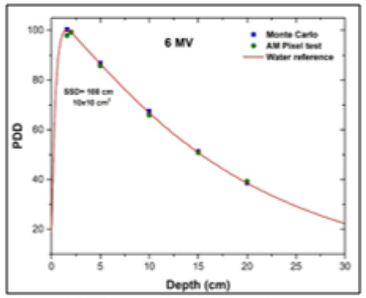
Active matrix pixel and DAQ electronic circuit.



Operation flowchart of the AM pixel, DAQ and microcontroller.



(a) Linearity response in terms of measured voltage as a function of delivered monitor units (MU) and acquired at three data collection times. (b) Dose rate response in terms of measured voltage as a function of dose rate (MU/min) and acquired at three data collection times. For the linearity and dose rate response, the system is more sensitive (higher voltage) when the collection time is the shortest.



Measured PDD data with the AM pixel compared to Monte Carlo simulations and clinically validated water PDD data.

Dante E. Roa PhD, DABR
Clinical Professor
Department of Radiation Oncology
UNIVERSITY OF CALIFORNIA – IRVINE HEALTHCARE
Chao Family Comprehensive Cancer Center
101 The City Drive South, Building 23, Rm 130 | Orange, CA 92868
Office: 714.456.8088 | Fax: 714.456.7170
Email: droa@uci.edu
USA