Journal of NUCLEAR SCIENCE and TECHNOLOGY, Supplement 4, p. 307–309 (March 2004)

# Development of front-end electronics for M-MSGC using individual-readout ASIC with resistive strip output

P. SIRITIPRUSSAMEE[1*], H. TAKAHASHI[1], JY.YEOM[1], T. ISHITSU[1], M. NAKAZAWA[1], S. KISHIMOTO[2], T. INO[2], M. FURUSAKA[b], K. SAKAI[3], H.M.SHIMIZU[4]

[1]*Department of Quantum Engineering and System Science, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656 , Japan*

[2]*High Energy Accelerator Research Organization (KEK), 1-1 Oho, Tsukuba 305, Japan*

[3]*Tokyo Institute of Technology, 2-12-1 O-okayama, Meguro-ku, Tokyo152, Japan*

[4]*The Institute of Physical and Chemical Research (RIKEN), 2-1 Hirosawa, Wako, Saitama 351-01, Japan*

A multi-grid-type microstrip gas chamber (M-MSGC) is being developed for the new spallation neutron source in Japan. The objective of this study is to provide a new position readout electronics for two-dimensional M-MSGC which can reduce the number of interconnections through a gas vessel by using a new encoding readout scheme based on ASIC technology. In order to test an ASIC based individual readout method, an ASIC chip, which has typically 16 individual input channels, has been designed and fabricated using a ROHM 0.35μm CMOS process and the chip was connected to a developed encoding circuit. The main results of the performance test indicated that the front-end electronics was able to encode 1500 pixels of the input position with 4.4% of position non-linearity. The results of this work confirm that the developed circuit would be appropriate for the front-end electronics of He-3 two-dimensional M-MSGC.

***Keyword: Gas detector, Multi-grid-type microstrip gas chamber (M-MSGC), readout method, ASIC***

## I. Introduction

Micro Strip Gas Chamber (MSGC) was first introduced by Anton Oed [1)] in 1988. It has several attractive characteristics such as mechanical stability, high gas gain, fast charge collection time, etc. However, MSGC was confronted with discharge problem [2-3)]. Thus several researches [3-4)] have proposed ideas to overcome the difficulty. One of solutions is a multi-grid-type microstrip gas chamber (M-MSGC) [5)], which is a new type of MSGC that is inserted with additional grid electrodes between the anode and the cathode. The grid electrodes realize a favorable electric field and remove surface charges for avoiding the streamer development that causes a discharge problem. To develop the two-dimensional M-MSGC [6-7)], floating electrodes (pads) are placed close to the cathode, which induce charges on the backside electrode. The induced signal could be used to define the position information depending on the thickness of the substrate and the induced charge would spread over several readout strips on the rear surface of the substrate. This dispersion affects the position resolution of the backside coordinate. In order to improve the position resolution, one approach is using individual readout method. However, this method requires so many interconnections that could affect the gas leakage problem. To avoid the difficulty, the encoder is needed. In our application, the front-end electronics is expected to be placed inside the chamber. Thus an Application Specific Integrated Circuit (ASIC) technology is preferable for its very small size. Consequently, we decided to develop a new encoding readout method based on the individual readout ASIC.

In next section we will describe the developed chip and the new encoding readout circuit. The experimental setup is described in section III, followed by the performance results of the readout method in section IV.

## II. Encoding circuit

### 1. Individual readout ASIC chip

Individual readout ASIC chips have been designed and fabricated using a ROHM 0.35 μm CMOS process with the aid of the VDEC chip fabrication service in Japan. The chip block diagram and layout are shown in **figure 1** and **2**, respectively. Test chips have 16 individual input channels, 32 digital output pins and 16 analog outputs. Each input channel is connected to a preamplifier, signal shaper and a variable gain amplifier (VGA) followed by three-level discriminators

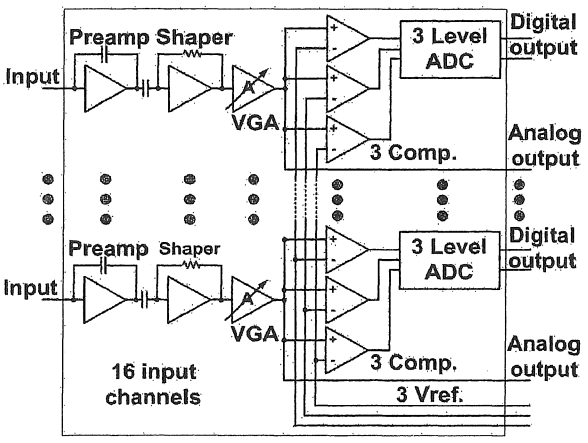


**Fig. 1.** Block diagram of individual readout ASIC chip

*Corresponding author. Tel.+8-35-841-6974,
Fax: +8-33-818-3455, e-mail: prasit@sophie.q.t.u-tokyo.ac.jp.

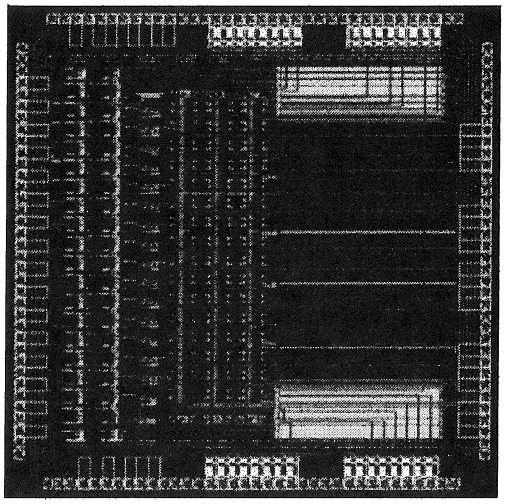

Fig. 2. Layout of individual readout ASIC chip

to provide coarse analog-to-digital conversion. In addition, the shaping time of the signal shaper was 500ns.

## 2. A new encoding readout circuit

An encoding readout circuit block diagram is given in **figure 3**. The digital output of each individual channel is connected to a digital-to-analog converter for re-encoding the signal into analog short pulses and then the signal is fed into a resistive line. The charge amplifier is used for gain up the encoded signals. Moreover, this encoder provides two signals (A and B) from both ends which can be decoded by using charge division method (A/(A+B) provides an input position).

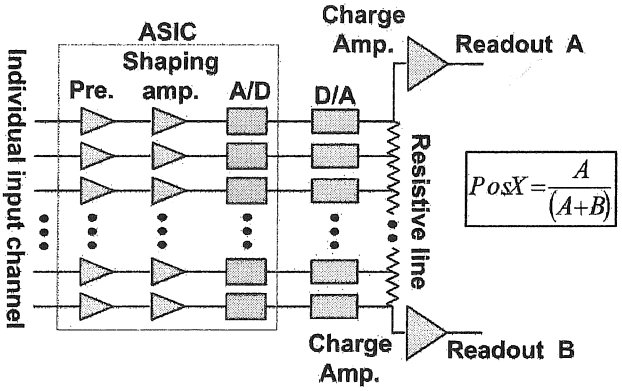


Fig. 3. Block diagram of the encoding readout circuit

## 3. Scalability in the proposed method

In order to increase the number of input channels, the output of several readout modules can be connected in series as shown in **figure 4**. In this case, the maximum number of input channels is limited by the position identification ability due to noise level of the developed circuit. To evaluate this limit we have performed a test measurement as described in next section. In addition, higher resistivity of the resistive line causes a longer signal collection time. This will pose another restriction in the scalability, So that low resistive line resistivity is required.

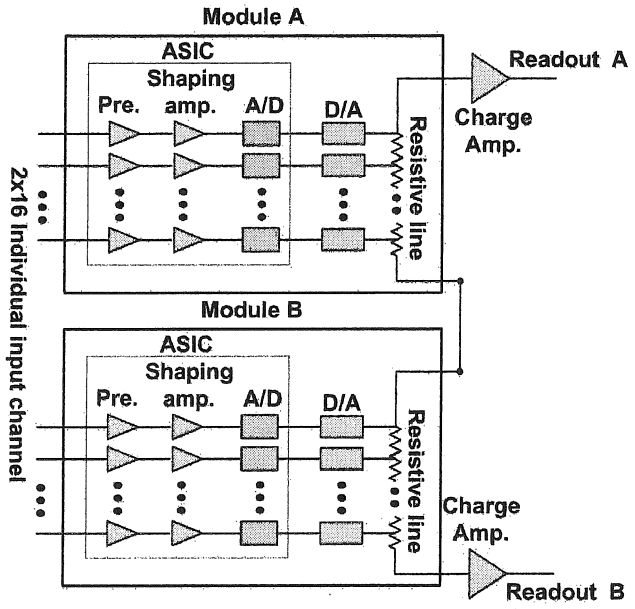


Fig. 4. Scalable input channel

# III. Experimental setup

One test chip was connected to the encoding circuit as shown in **figure 5**. One digital output signal of each individual channel was connected to the resistive line through a one-shot circuit (74HCT221) that could re-encode the digital signal to the short pulse analog signal (80ns) and then the signal was fed into a resistive line (765Ω). To improve the position linearity, additional resistors (300Ω) were connected to both ends of the resistive line. In order to decode the signal, both readout signals were converted to amplifier and a two-dimensional MCA to decode the input position. In the performance test, 100mV test pulse fed through a 1pF capacitor was used as an input signal.

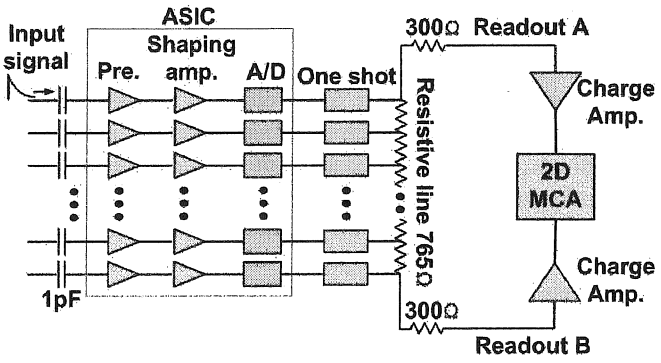


Fig. 5. Experiment setup

# IV. Results and Discussions

## 1. Position identification

According to the experiment, test pulse signal was connected to the input channel and using the charge division method to decode each input position. The decoded positions were illustrated in **figure 6**. As in the figure, 16 peaks were observed and each peak corresponded to the input channels. This inferred that the developed readout method was successfully to resolve the entire individual input positions.

Moreover, FWHM (Full Width at Half Maximum) of decoded position and distance between neighboring peaks were found to be 2-4 and 240-260 channel numbers, respectively. The ratio of average FWHM to average distance between neighboring peaks stood at 1.05:100. Thus, the maximum number of input positions that our system could resolve is

$16 \times \frac{100}{1.05} \approx 1500$ pixels.

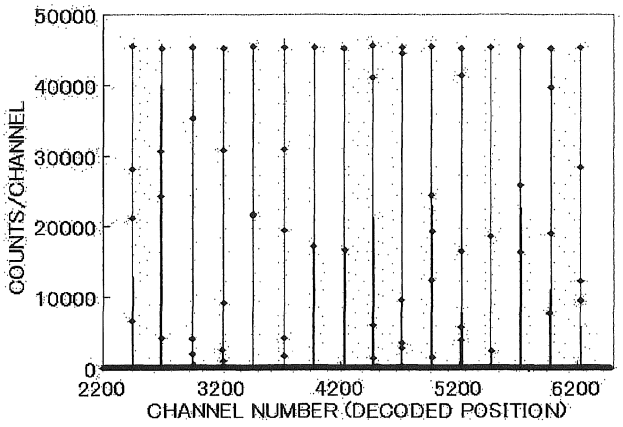


**Fig. 6.** Position identification

## 2. Position linearity

Position linearity of the readout method was shown in **figure 7**. The integral non-linearity (INL) was 4.4%INL. The source of the INL may be due to the error of resistive line.

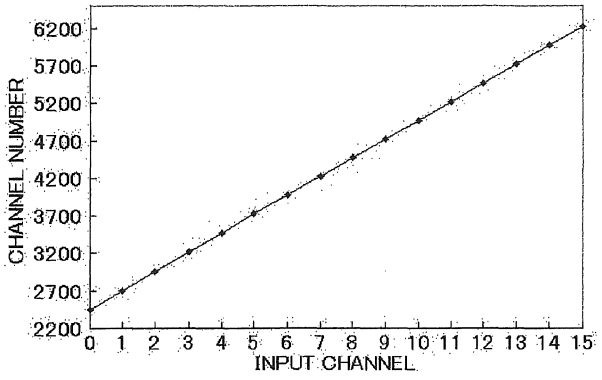


**Fig. 7.** Position linearity

## V. Conclusions

The new encoding readout method has been developed for the M-MSGC front-end electronics. The individual readout ASIC chips have been designed and fabricated using a ROHM 0.35μm CMOS process. The test chips have 16 individual input channels. The performance test results showed that the readout method was able to resolve the entire individual input position. The maximum number of input channels was estimated to be about 1500 channels when we used a cascade connection of multiple modules. The position linearity of the readout method was 4.4% (INL). The results confirm that the developed circuits have been ready for use as the front-end electronics of M-MSGC.

## VI. Acknowledgements

The authors like to thank the VLSI Design and Education Center at the University of Tokyo for the electronic beam drawing system.

## VII. Reference

1) A. Oed, "Position sensitive detector with microstrip anode for electron multiplication with gases", Nucl. Instrum. Methods, **A263** 351 (1988)

2) V. Peskov, B. D. Ramsey and P. Fonte, "Surface streamer breakdown mechanisms in microstrip gas counters", Nucl. Instrum. Methods, **A392** 89-93 (1997)

3) S. Keller, et al., "Sparks in MSGCs", Nucl. Instrum. Methods, **A419** 382-387 (1998)

4) A. Nowack and A. Zander, "Operation of MSGC+GEM detectors in a high rate environment", Nucl. Instrum. Methods, **A478** 250-253 (2002)

5) D. Bouvet, , V. Chorowicz, et al., "Radiation hardness and ageing properties of small gap plus GEM chambers", Nucl. Instrum. Methods, **A485** 322-327 (2002)

6) H. Takahashi, K. Yokoi, K. Yano, et al., "A new multi-grid type MSGC with pad readout", Nucl. Instrum. Methods, **A471** 120-124 (2001)

7) H. Takahashi, K. Mori, et al., "Development of a new multi-grid-type microstrip gas chamber", Nucl. Instrum. Methods, **A477** 13-16 (2002)

8) Kazuki Yano, Hiroyuki Takahashi, et al., "Development of $^3$He MSGC for Neutron Scattering Experiment", IEEE Trans. Nucl. Sci., **Vol.49** 1634-1637 (2002)