AXAF Science Center

Harvard–Smithsonian Center for Astrophysics

MEMORANDUM

July 9, 1996

To: Distribution

From: M. Juda

Subject: HRC Position Logic

File: /data/juda1/juda/asc/hrc/tex/hrc_positions.tex

1 Introduction

This memo is a summary of how the HRC instrument generates the telemetry information on event positions.

The HRC uses a crossed grid charge detection scheme to register the position of the charge cloud produced by an event emerging from the bottom of the MCP stack[1]. This method was used for the *Einstein* and *ROSAT* HRIs. A detailed explanation of the operating principle of the crossed grid charge detector (CGCD) can be found in Chappell & Murray (1989)[2]. Briefly, the HRC CGCD consists of two planes of "wires" that run perpendicular to each other. As shown in figure 1, adjacent wires along a single axis are connected via resistors and every eighth wire is connected to a charge amplifier. The charge that is deposited on an individual wire is divided between the two nearest charge amps in inverse proportion to the ratio of resistances from the wire to the amps. Using the signals from the three amplifiers centered on the charge cloud, the

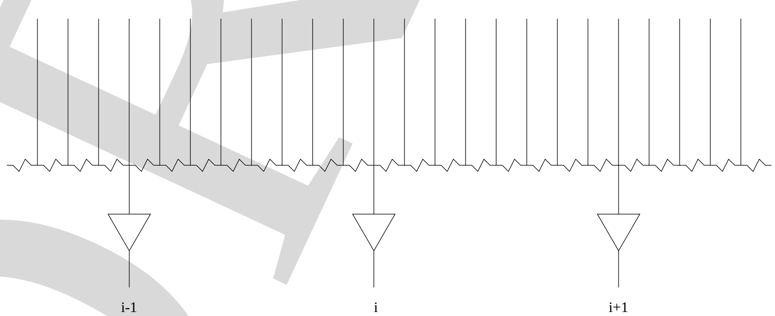

Figure 1: Crossed grid charge detector wires and taps

event position relative to the central amplifier can be determined via a "three tap position algorithm"[2]:

$$X_{fine} = \frac{A_{i+1} - A_{i-1}}{A_{i-1} + A_i + A_{i+1}}.$$

This algorithm can be further modified to account for "gaps" caused by incomplete charge collection[2]. This X_{fine} is added to the event's coarse position, X_{coarse}, given by the number of the tap that is the center of the distribution.

The event coarse position is determined by the HRC instrument by the following process (all accomplished using analog and digital hardware components): An event is detected when the signal from the back MCP exceeds a commandable threshold value. Once the event is detected the signals from the taps on the CGCD are sampled and compared to a threshold. A set of "UP" and "DOWN" priority encoders are used to determine the lowest and highest tap numbers for which the signals exceeded the threshold. These two numbers are averaged to return a candidate coarse position (the UP encoded value is added to the inverted DOWN encoded value and divided by 2). The two taps that bracket the candidate coarse position (or the candidate and the next higher) are compared to each other to determine the higher value and that tap number becomes the actual coarse position. This tap signal and the two adjacent signals are selected for further processing. The three signals are input to amplifiers with selectable gains for which the gain settings are determined by the amplitude of the pulse from the bottom MCP. The selected scale factor for each event appears in the telemetry. Finally, the three signals are input to ADCs for conversion to serial digital data for output into the telemetry stream.

2 HRC-I

The HRC-I CGCD is produced by winding wire around a ceramic block and removing wire from the back side to produce a linear array of parallel wires for each axis. There are 473 wires along each axis at a pitch (distance between wires) of 0.008100 in (0.20574 mm) resulting in a distance between taps of 1.6459 mm and an overall span of 97.109 mm (472×0.20574 mm); this range is larger than the open area of the HRC-I MCP. With a tap every eighth wire, the 479 wires per axis are sampled by $\sim$60 taps. The HRC-I CGCD uses 59 taps per axis with a tap at each end provided by charge amps connected to wires 1 and 473. The origin of the HRC-I coordinate system is at the spacecraft +Z axis extreme corner of the HRC-I as shown in figure 2[3]. The U axis runs toward the +Y extreme corner while the V axis runs toward the -Y corner.

3 HRC-S

The design for the HRC-S CGCD is discussed in more detail in Kenter et al.[4] but it is similar in concept to the HRC-I. For the HRC-S the "long wires", those that give the position in the cross-dispersion direction are produced by patterning a layer of gold deposited directly on the ceramic block. The wires for the dispersion direction are produced by winding wire around the ceramic block and removing it from the back side. There

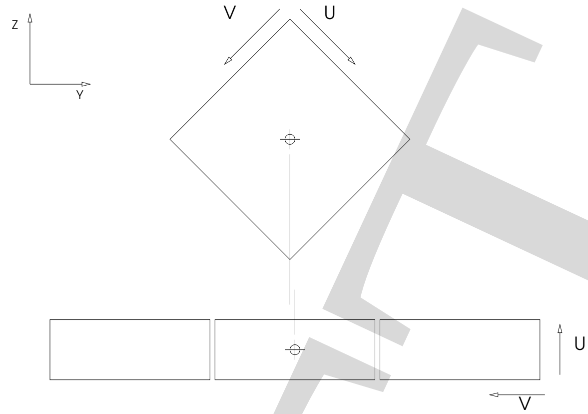

Figure 2: HRC coordinate system

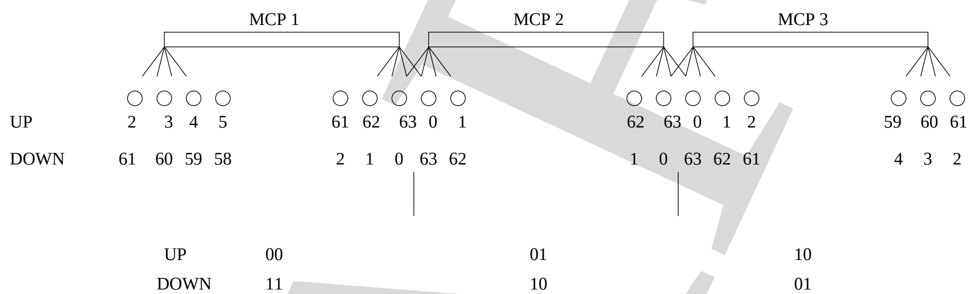

Figure 3: HRC-S coarse position logic

are 1513 wires along the dispersion (V) axis and 121 "wires" along the cross-dispersion (U) axis. The wire pitch for both axes are the same as for the HRC-I (0.2057 mm) and as a result so is the distance between taps. The V-axis runs anti-parallel to the spacecraft Y-axis while the U-axis is parallel to the Z-axis. Note that the handedness of this coordinate system is different from that of the HRC-I.

The HRC-S provides a continuous position readout along the dispersion direction ∼311 mm long while three MCP segments are required to span this distance. The 1513 wires along the dispersion direction should take ∼189 taps for complete coverage; the HRC accomplishes this with 64 charge amplifiers by connecting three different taps to a single charge amp and using which MCP segment provided the trigger signal to break the redundancy in coarse position. The U axis uses 16 taps to span its 121 wires. A 100 mm long MCP segment only spans a length of ∼61 taps and at the gaps between the MCP segments the charge cloud could come from either MCP. Figure 3 shows a schematic layout of the HRC-S position logic[5]. To produce a continuous readout, the logic in table 1 is implemented in the HRC prior to the priority encoding scheme used to determine the coarse position. The resulting coarse position range goes from 2 to 189 with the center of the central MCP at a nominal coarse position of 95.5. Events with coarse positions of 64 or 65 could logically come from either MCP 1 or 2, similarly events with coarse positions of 126 or 127 could logically come from either MCP 2 or 3; only the proximity of the edge of the MCP to the tap and the intrinsic resolution of the HRC-S makes one MCP more likely than the other to be the source of the signal. Table 2

Table 1: HRC-S Coarse Position Logic

UP Encoding				DOWN Encoding			
MCP	Taps	V-axis Bit 6	Bit 7	MCP	Taps	V-axis Bit 6	Bit 7
1	2–63	0	0	1	0–61	1	1
1	0–1	1	0	1	62–63	0	1
2	0–63	1	0	2	0–63	0	1
3	62–63	1	0	3	0–1	0	1
3	0–61	1	1	3	2–63	1	0

lists the nominal ends in coarse position units of the HRC-S MCP segments (based on a nominal central coarse position for MCP 2 of 95.5). Reasonable dividing points for labeling an event as originating on a specific MCP are at coarse positions 64.544 and 126.457.

Table 2: HRC-S MCP segment ends

	Low	High
MCP 1	3.224	63.965
MCP 2	65.122	125.878
MCP 3	127.035	187.792

References

[1] Murray, S.S. & J.H. Chappell, ”The Advanced X-ray Astrophysics Facility High Resolution Camera”, SPIE, 982, 77, 1988.

[2] Chappell, J. H., & S. S. Murray, “Position Modeling for the AXAF High Resolution Camera (HRC)”, Proc. SPIE, 1159, 460, 1989.

[3] Communication from J. Gomes

[4] Kenter, A., R. Goddard, J. Gomes, J. Lessing, S.S. Murray, R. Moore, R. Roll, M. Valenza, and M. V. Zombeck, ”The MCP Readout for the AXAF-I Grating Spectrometer”, Proc. SPIE, 2009, 84, 1993.

[5] SAO-HRC-DR-95-137, “Technical Review Documentation: Presentation Charts for the HRC Critical Design Review (CDR)” March 1995.