The K4 Correlator

Shin’ichi HAMA¹, Hitoshi KIUCHI², Mamoru SEKIDO², and Michito IMAE²

¹Communications Research Laboratory, 4-2-1 Nukui kita-machi, Koganei, Tokyo 184, Japan  
²Communications Research Laboratory, 893 Hirai, Kashima, Ibaraki 314, Japan

Abstract. Communications Research Laboratory, Japan has developed an XF type VLBI correlation processor (K4 correlator) dedicated for K4 system and are now testing its performance. K4 correlator is compact and fast up to 32 Msp/ch. And it can process two-bit sampled data and millisecond pulsar’s data. We are also developing a new software taking compatibility with the present software (KROSS) into account.

1. Introduction

Communications Research Laboratory, Japan (CRL) developed an XF type VLBI correlation processor (K3 correlator) in 1983. It had been an only VLBI correlator in Japan and has served in both geodetic and astronomical field. But recent rapid increase of VLBI experiments in Japan made us to decide to develop a new XF type correlation processor (K4 correlator) dedicated for K4 recorders. We have developed it and are now testing its performance.

2. Outline of K4 Correlator

Figure 1 shows the appearance of K4 correlator and Fig. 2 shows its block diagram. It consists of 16 units with a hard disc and a controller. This XF type correlator supports ordinary geodetic experiment on a single baseline. Though only one set was made, an expansion up to five baselines is done simply by adding of other sets without any modification. In case of K3 correlator we need to communicate with a computer to know a time which is been reproduced, but we only need to look at a display to know it in case of K4 correlator.

As Table 1 summarizes, the performance of the K4 correlator is much improved compared to K3 correlator (SUGIMOTO et al., 1991). On the other hand, we made K4 correlator as compatible as possible with K3 correlation system so that we can reduce time and money required for its development.
Fig. 1. Appearance of K4 correlator.

Table 1. Comparison of correlators between K3 and K4.

<table>
<thead>
<tr>
<th></th>
<th>K3</th>
<th>K4</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>usable recorder</td>
<td>K3, K4</td>
<td>K4</td>
<td></td>
</tr>
<tr>
<td>speed</td>
<td>8 Mbps/ch</td>
<td>32 Mbps/ch</td>
<td></td>
</tr>
<tr>
<td>2b sampled data</td>
<td>no</td>
<td>OK</td>
<td></td>
</tr>
<tr>
<td>lag</td>
<td>8/ch.</td>
<td>16/ch.</td>
<td></td>
</tr>
<tr>
<td>(d_{\tau_2})</td>
<td>128 b/PP</td>
<td>1024 b/PP</td>
<td>12.6 b/s max*</td>
</tr>
<tr>
<td>pulsar gate</td>
<td>1/PP</td>
<td>any times</td>
<td>700/s **</td>
</tr>
<tr>
<td>distribute data</td>
<td>no</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>P-cal</td>
<td>10 kHz</td>
<td>selectable</td>
<td></td>
</tr>
<tr>
<td>size (cm)</td>
<td>76 \times 180 \times 80</td>
<td>45 \times 31 \times 46</td>
<td></td>
</tr>
<tr>
<td>weight (kg)</td>
<td>250</td>
<td>32</td>
<td></td>
</tr>
</tbody>
</table>

*4 Mbps, on the earth.
**For PSR1937 + 21.

3. Performance of K4 Correlator

This section describes the features of K4 correlator.

(1) For K4 recorders

Domestic VLBI experiments in Japan are now carried out with K4 recorders (HAMA and KIUCHI, 1991) which are developed by CRL. K4 recorders and K4 tapes are compact, light-weight, and easy to treat. So, K4 correlator is dedicated for K4 recorders. K4 correlator covers not only traditional 4 M (or 8 M) bps x 16 channel mode but also almost all the modes which are supported by the New K4 acquisition terminal (KIUCHI et al., 1993). Though K4 recorder doesn’t have common mode (selecting a particular track channel and dividing it to all the channel), K4 correlator have a function of the common mode.
The K4 Correlator

Fig. 2. Block diagram of K4 correlator.
Fig. 3. Two-bit correlation (weighting factor = 3, low bit product deleted). (In case of using only up counter for accumulation.)
(2) High speed up to 32 Mspss
K4 correlator can process high speed data up to 32 Mspss (samples per second) by making use of high speed programmable ICs. As the actual total bit rate of the K4 recorder is 256 Mbps, possible highest processing speed is 32 Mspss \times 8 \text{ channels or} \ 16 \text{ Mbps} \times 16 \text{ channels.}

(3) Accept two-bit sampled data
K4 correlator can process two-bit sampled data. We adopted such algorithm for two-bit correlation that weighting factor is 3 and low level product is deleted (COOPER, 1970). Then the basic circuit is simplified as shown in Fig. 3. The software for two-bit sampled data processing is being developed.

(4) Gating for millisecond pulsars
The K3 correlator can open and close pulsar gates only once per PP (parameter period; a priori parameter given to the correlator is not changed within a PP), which can’t process millisecond pulsar’s data. But K4 correlator can work the gating any times in a single PP.

(5) Compact and light-weight
We achieved such a compact and light-weight correlator as $45 \times 31 \times 46 \text{ cm}$ and 32 kg by making use of two kinds of FPGAs (Field Programmable Gate Array); LCA (Logic Cell Array) and Quick Logic. Now we can carry and use a correlator at any observatory like a spectrum analyzer.

(6) Detect any P-cal frequency
Though K3 correlator tracks only 10 kHz P-cal signal, K4 correlator can detect any P-cal frequency. When we conduct a ZBI (Zero Baseline Interferometry) or a short baseline VLBI, we can adopt different P-cal frequency for each station.

(7) For real time VLBI
When an appropriate communication link is provided, real time VLBI is possible up to what is shown in Fig. 4, by a 32 Mbit/channel buffer. At 4 Mbps/ch,
real time VLBI with K4 correlator covers all over Japan.

(8) Utilize VME

K4 correlator is installed in a VME system which bears Motorola 68040 CPU. Figure 5 shows the flow of data and control line. The correlator and the data recorders are controlled by HP330 personal computer through GPIB by making use of present correlation software KROSS (Takahashi et al., 1991). But the data are not transferred to HP330 but to the internal HD (hard disc) through VME back plane.

4. Conclusion and Acknowledgement

CRL has developed an XF type VLBI correlation processor (K4 correlator), which has high speed and ability. We are now testing its performance.

We thank Cosmo Research Co. who has developed K4 correlator with us and also thank to Dr. Tetsuro Kondo who gives us many useful comments.

REFERENCES