VLB ARRAY MEMO No. 93

NATIONAL RADIO ASTRONOMY OBSERVATORY
Green Bank, West Virginia

MEMORANDUM June 10, 1982

To: VLB Working Group

From: R. Lacasse

Subj: Data Digitization Electronics, Draft 2

This memo supercedes VLBA memos 57 and 60.

System Description

The function of manipulating the four wideband IF signals from the Vertex Cabin into four bit streams suitable to the recorder is performed by the Data Digitization Electronics (DDE). A few miscellaneous functions, as discussed below, are also performed by the DDE. As shown in Figure 1, the DDE consists of an IF Processor, four IF to Video Converters, a Sampler, Delay Calibration, Time of Day Clock, RS232 Distributor, and 5 MHz Distributor. The design is based on the Mark III system, modified for fewer converters with wider bandwidths, and with the data formatting and quality monitoring left to the recorder electronics.

As shown in Figure 2, the IF Processor has four IF inputs in the band from 300 MHz to 1500 MHz. Each of these inputs is frequency translated, with 10 kHz resolution, such that the lower edge of the band of interest is at 500 MHz. This section of the DDE is best implemented in the Vertex Cabin, to avoid sending wideband signals through long lengths of cable and then having to deal with the resulting frequency dependent cable attenuation.

As a result of the frequency agility of the IF Processor, the Video Converters can be relatively simple. Primarily, they frequency translate the outputs of the IF Processor to baseband, using fixed 500 MHz oscillators, and single sideband networks. The Video Converters also provide IF level setting attenuators, and selectable output bandwidths of 25 MHz, 12.5 MHz, 6.25 MHz, 3.123 MHz, 1.56 MHz, 0.78 MHz, 0.39 MHz, 0.19 MHz, and 0.10 MHz. Video, IF, and LO power levels are monitorable.

The Sampler produces one-bit, 2 level samples of the filtered, baseband data at a maximum rate of 50 Mbps. The sampling clock is derived from the 5 MHz reference using phase-locked techniques; oversampling is easily accomplished for the narrow bandwidths. Both the sampled data streams and the sampling clock are transmitted to the recorder. A Time-of-Day Clock output is also transmitted to the recorder.

The Delay Calibrator in the DDE is the same as that used in the Mark III system with the exception that it also includes a self-contained counter and communicator module. The Delay Calibrator provides a 5 MHz reference to the Vertex Phase Calibrator System, and also measures the round trip delay in the 5 MHz reference cable.

Communication to the host computer is implemented as in the Mark III system: each module includes an RS232 transceiver which is assigned an address on an RS232 link. A module responds according to a well defined protocol when it is addressed. Thus, all significant functions in the DDE are remotely controllable and/or observable.

Hardware costs are broken down in Table 1, and manpower requirements in Table 2.

Comparison with Existing MKIII System

The Data Digitization Electronics (DDE) must handle up to four, 25 MHz wide, IF signals to produce data at up to 200 Mbits/sec. A system permitting unattended operation for at least 24 hours is also very desirable, to minimize operating costs.

The existing MKIII system, with a few modificaitons, would be suitable for this application. The modifications include an IF distributor upgraded to handle four IF's and automated video converter patching. They also include Video Converter and Formatter modifications appropriate for the bit rate specification. Also, the recorder must be upgraded for a factor of 10 or 20 increase in bit density. The first two modifications are technically straightforward. Work at two institutions is in progress to realize the third modification. Multiple recorders are required to accommodate 24-hour unattended operation. Using 12,000 foot reels of tape instead of the standard 9,200 foot reels, and assuming a factor of 20 improvement in density, four recorders would be required for 24-hour operation. With only a factor of 10 improvement in density, eight recorders would be required.

The DDE, as proposed, is similar to the MKIII system in basic architecture. However, a cost savings is realized by using fewer video converters (four) with broader bandwidth ($\leq$ 25 MHz). A further cost savings is realized in the IF distributor since patching to various permutations of 14 video converters is not required. The appropriate IF signals are routed directly to the video converters by the IF switching matrix in the Vertex Cabin. For purposes of comparison this system is dubbed MKIII.1.

Cost of alternative recorder implementations is covered in another section. Therefore, a cost comparison of only the electronics required to translate four IF's into four bit streams is covered here. This comparison is detailed in Table 3. The significant differences are the following. A 29 K savings is realized in Video Converters in the MKIII.1 system since four instead of fourteen are required. The MKIII.1 system includes a Formatter in the recorder, so all that is required in the DDE are a Sampler and Clock. The 13 K for the MKIII IF Distributor includes the cost of the upgrade mentioned above. Both systems require an IF Processor to switch the nineteen receiver IF's into four and to select the band of interest from the broadband receiver output. The MKIII.1 IF Processor is more expensive since it includes some of the functions of the MKIII IF Distributor. A Decoder is included in the MKIII.1 recorder, and so is not included in this cost estimate.

A fair comparison must also include manpower and spares costs. These are detailed in Tables 4 and 5, respectively. Table 4 shows that the MKIII.1 design effort time is more than compensated by the reduced assembly and test time. Spare costs are similar.

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TABLE 1

Data Digitization Electronics Hardware Cost Breakdown

Item	Cost
IF Processor	$36 K
IF to Video Converters	13 K
Sampler	2 K
RS232 Distributor	1 K
Delay Calibrator	3 K
Rack, Power Supplies, Connectors, etc.	10 K
5 MHz Distributor	2 K
Total	$67 K

TABLE 2

Data Digitization Electronics Manpower Requirements

Item	Time (Man-Months)
Design and Document	15
Order	1
Assemble (1 terminal)	8
Total	24

TABLE 3

Cost Comparison of MKIII and MKIII.1 Data Digitization Electronics

MKIII	MKIII	MKIII.1
Video Converters	$ 42 K	$ 13 K
Formatter	6 K	-- *
Sampler	--**	1 K
Clock	--**	1 K
IF Distributor	13 K	--
IF Processor	28 K	36 K
Delay Calibrator	2 K	3 K
Counter	1 K	--
5 MHz Distributor	2 K	2 K
Rack, Supplies, Connectors, etc.	11 K	10 K
Decoder	4 K	-- *
TTY Distributor	1 K	1 K
Totals	$110 K	$67 K

* Part of recorder.

** Part of formatter.

TABLE 4

Comparison of Manpower Requirements for the MKIII and MKIII.1 Systems

Item	Time (Man-Months)	
	MKIII	MKIII.1
Design and Document	2	15
Procurement	1	1
Assembly and Test (per unit)	15	8
Total (one unit)	18	24
Total (ten units)	153	96

TABLE 5

Comparison of Spares Costs for MKIII and MKIII.1 System

Item	MKIII	MKIII.1
Video Converter	$ 3 K	$ 3.2 K
Formatter	6 K	--
Sampler	--	1 K
Clock	--	1 K
IF Distributor	13 K	--
IF Processor	28 K	36 K
Delay Calibrator	2 K	3 K
Counter	1 K	--
5 MHz Distributor	2 K	2 K
Supplies, Connectors, etc.	3 K	3 K
Decoder	4 K	--
TTY Distributor	1 K	1 K
Total	$63 K	$50.2 K
Assembly and Test Time (Man-Months)	22	20

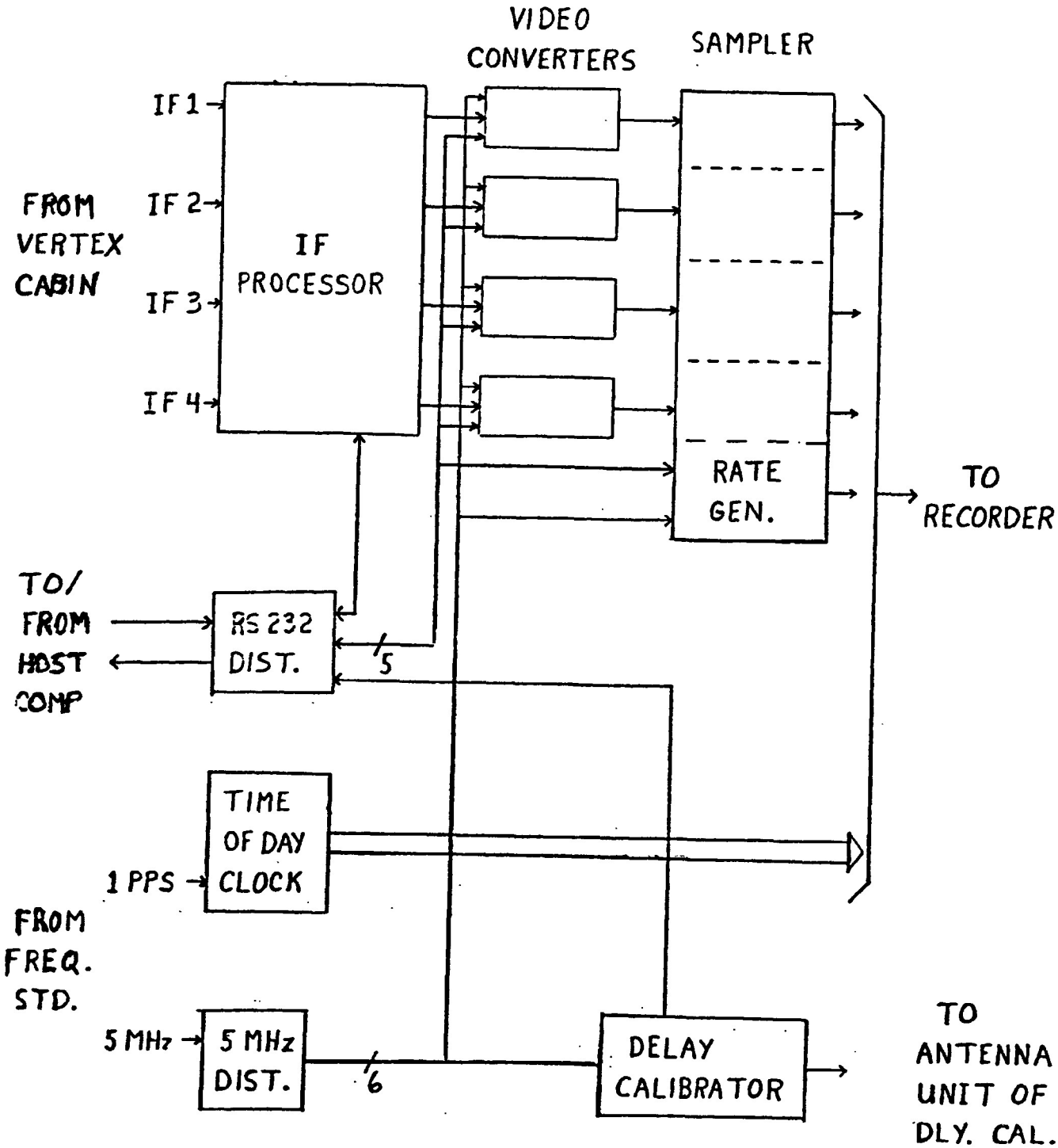

FIGURE 1

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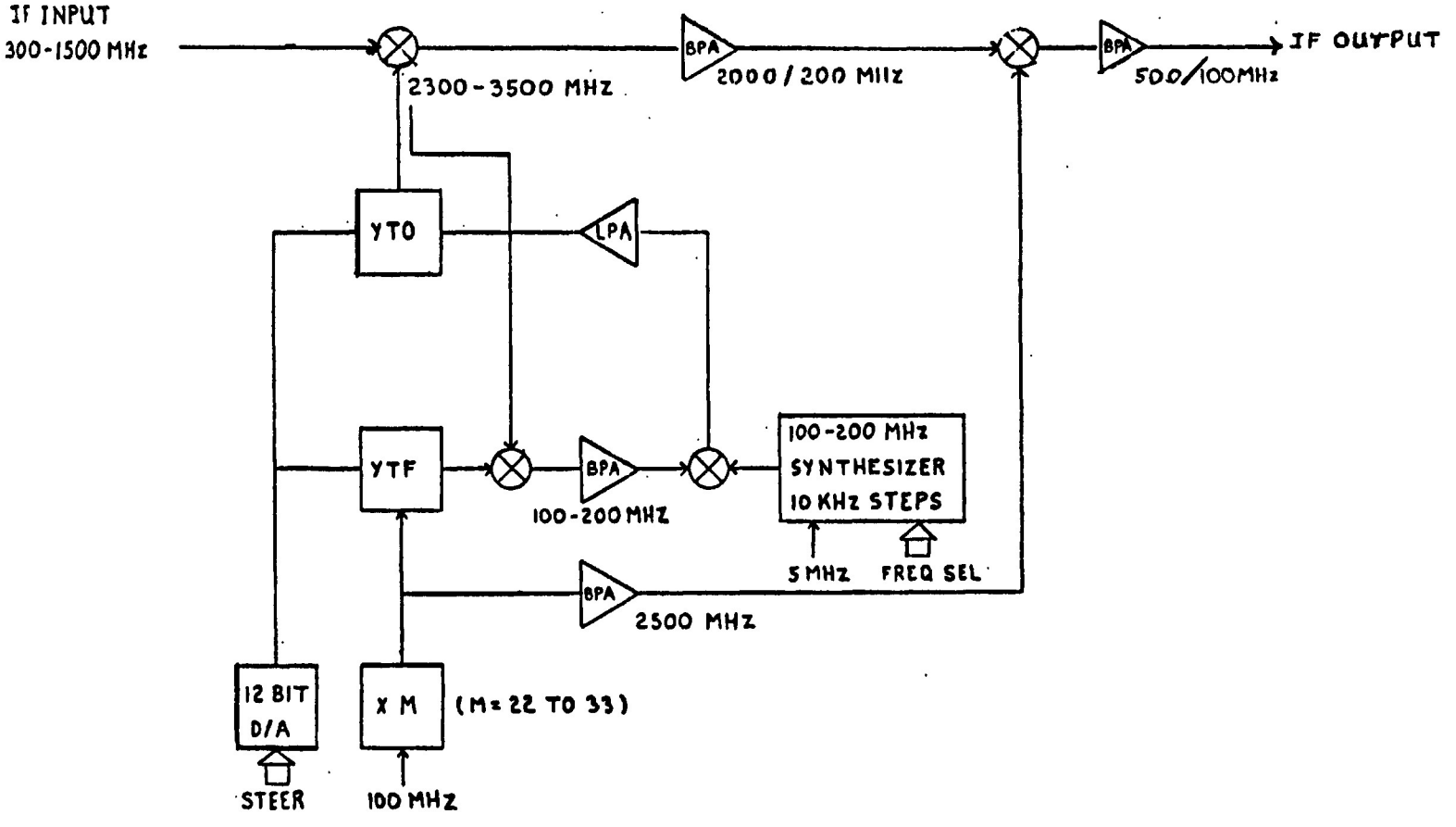

NOTE: ONLY ONE OF FOUR IDENTICAL CHANNELS IS SHOWN.

YLBA IF PROCESSOR
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FIGURE 2