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Spectral Processor Memo No. 27

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To: Spectral Processor Project Group

From: R. Fisher

Subj: Dedispersion with an Accumulator Memory Address Generator

This note is a brief description of the dedispersion scheme proposed for the spectral processor. This scheme is one of several accumulator address generation modes which will be available.

There are two sections in the spectral processor, and each section has its own accumulator as shown in Figure 1. Since the two accumulators are identical the same description will apply to both.

The input to the accumulator is a continuous series of 512-channel power spectra arriving as fast as one spectrum every 12.8 μs. The output of the accumulator in the simple dedispersion mode is a stream of power samples each of which contains the sum of all of the frequency channels properly delayed to compensate for differential arrival times across the spectrum. The accumulated power samples could be averaged and dumped at any multiple of 12.8 μs.

Suppose for the moment that the accumulator memory has an infinite number of accumulation cells, and let successive cells (addresses) represent successive time samples of pulsar radiation. In the absence of dispersion all of the frequency channels in each spectrum would be added together in the same cell, and the cell address would be changed at a rate dictated by the required time resolution. For example, if the time resolution were 128 μs, all channels from ten successive spectra would be added to the same cell before moving on to the next cell. One cell address interval could then represent 128 μs of time.

Now, if the pulsar radiation is dispersed, not all channels in one spectrum want to end up in the same cell. If we take the convention that higher cell addresses represent later times, then from any one spectrum the higher frequency channels would want to be added to cells with higher addresses relative to the lower frequency channels. This has the effect of delaying the high frequency information with respect to that from lower frequencies. One could say that the spectrum is mapped into the time domain according to the dispersion function, and as time progresses this map slides to higher cell addresses. From the point of view of one cell, contributions to its sum begin arriving earlier from the high frequency channels than from low frequencies.

Of course, the accumulator does not need to be infinitely long, and it makes a lot of sense to break it into a limited amount of fast memory and a lot of slow memory. For practical reasons only one frequency channel can be added to one cell at a time and this must happen in 25 ns. (Actually some parallelism can slow this to 100 ns.) This high speed memory is expensive so as soon as a cell has received all of its information from the lowest frequency channel its contents can be dumped to cheaper low speed memory (computer memory) and returned to the high speed pool. Hence, the memory addresses commutate instead of increasing indefinitely. Figure 2 shows a schematic representation of the dispersion mapping in a finite memory. Not shown is the fact that when a cell reaches the right-hand end of the accumulator its contents are dumped.

The size of the fast memory bank is pretty well determined by the number of channels in the spectrum. There is a very little more information to be gained from retaining a time resolution finer than 1/4 or 1/8 of the traversal time of a dispersed pulse across one frequency channel, so the number of cells need not be greater than 4 to 8 times the number of channels. With wide bandwidths and large dispersions each cell must be capable of holding the sum of a large number of samples. We are planning 28-bit cell sizes which should hold about 10 seconds worth of data before overflow which is sufficient for a dispersion measure of about 2000 for a center frequency of 200 MHz, a bandwidth of 20 MHz, and a time resolution of 1/8 of a single channel crossing time.

Almost any shape of dedispersion curve could be accommodated with this scheme. If more than one cell can be dumped in a resolution time the curve need not be monotonic. For instance, different parts of the spectrum could be tuned to different dispersions.

Figure 3 shows the address generation scheme for the accumulator. The numbers in this diagram assume that all 512 channels are handled by the same accumulator, but, in practice, the accumulator will be split four ways. The RAM contains the dedispersion map with each location containing the address offset of an accumulator cell. To this address is added the time dependent address counter which increments at an interval which must be a multiple ($\leq$ 8) of the address RAM cycle time. Any overflow bit resulting from the addition is discarded.

Figure 2 shows a "bad data counter" block. This auxiliary accumulator keeps track of the amount of data that may not be added to the main accumulator cells because of the detection of wideband noise or because some frequency channels are dropped from the average. Because time and frequency holes map into the time domain in a complicated way, each accumulator cell must have a mate in the "bad data counter" block to record its history until dump time. Both use the same address.

JRF/cjd

Attachments:
Figures 1-3

SPECTRAL PROCESSOR

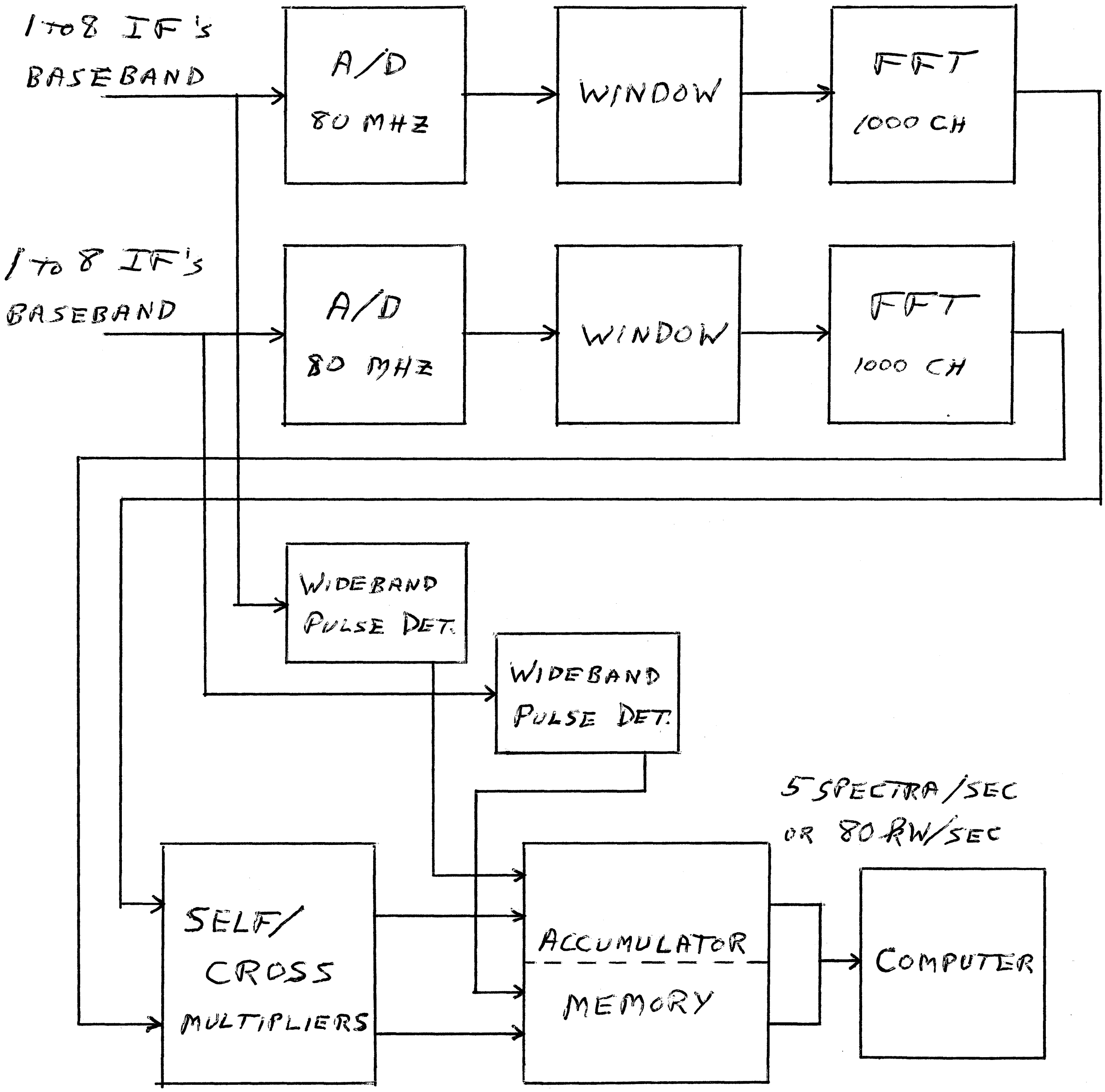

FIGURE 1

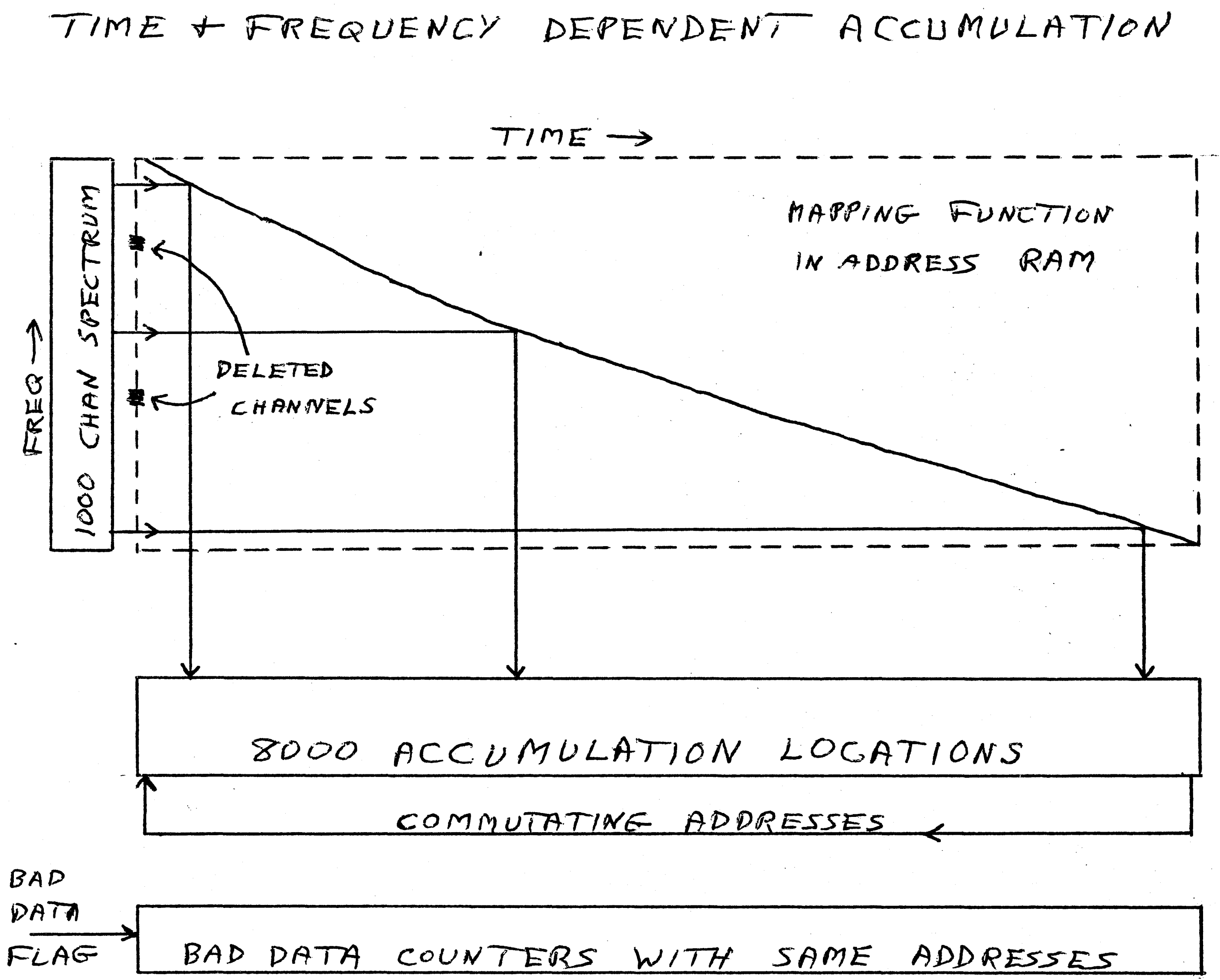
TIME + FREQUENCY DEPENDENT ACCUMULATION
TIME →
FREQ →
1000 CHAN SPECTRUM
MAPPING FUNCTION
IN ADDRESS RAM
DELETED
CHANNELS
8000 ACCUMULATION LOCATIONS
COMMUTATING ADDRESSES
BAD
DATA
FLAG
BAD DATA COUNTERS WITH SAME ADDRESSES

FIGURE 2

ACCUMULATOR ADDRESS GENERATOR

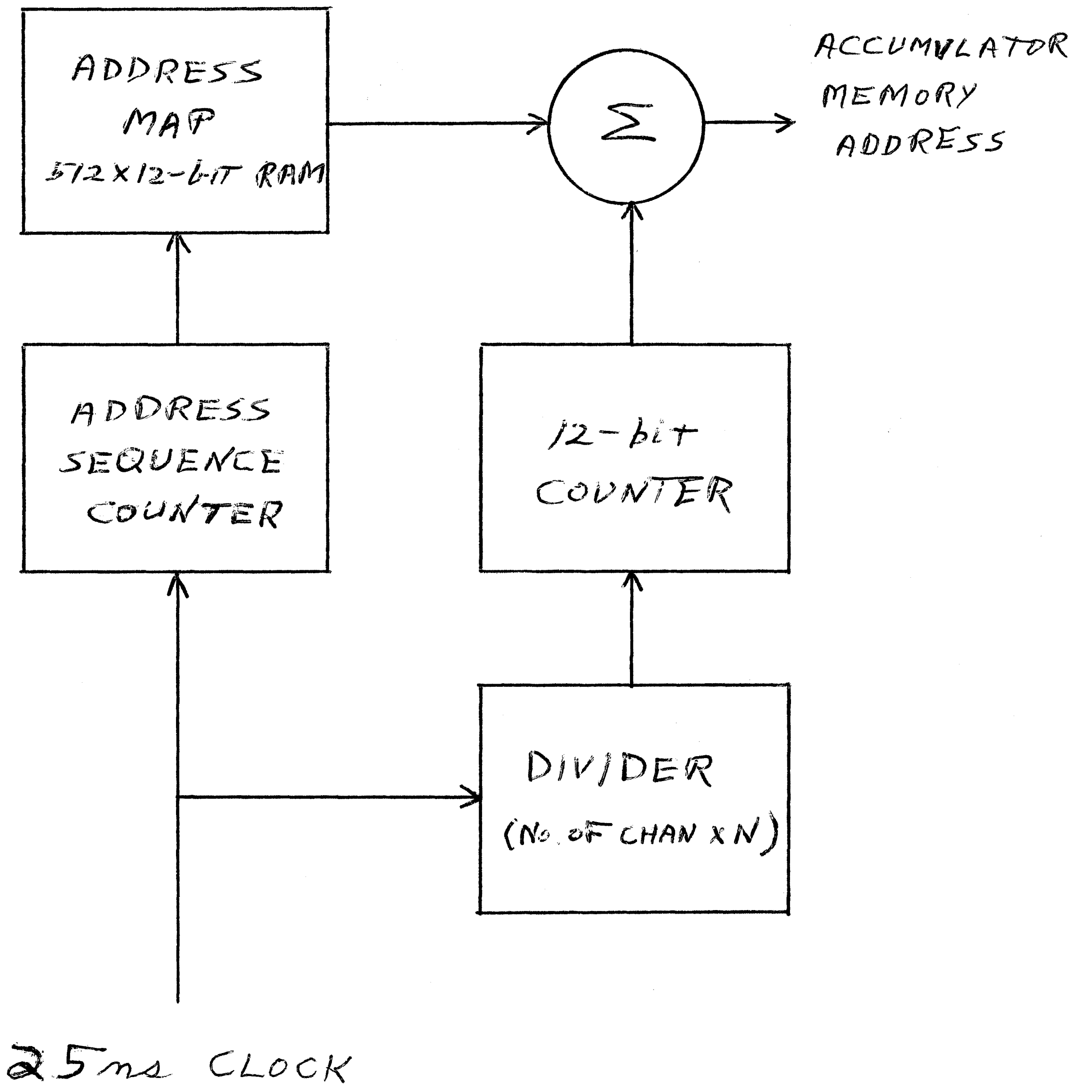

FIGURE 3