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To: VLBA Data Acquisition Group

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Subject: Proposed phase cal extractor for upgraded formatter A/D board

Block Diagram

Several schemes for phase cal tone extraction (and sampler threshold counts – D.C. tone) have been considered. This memo describes the characteristics of the method presently thought most promising. The method is to perform multiplication by a 2-bit sine and cosine function using a look-up table for each 32 MHz clock cycle. 1-bit and 4-bit modes can also be supported.

Memory size

In order to provide extraction frequencies in steps of 10 kHz for 0 to 16 MHz, a look-up table for 3200 clocks cycles (100 μsec) plus 2 data states (logical zero or 1), for a total of 13 address bits, is needed. For 2-bit sine and cosine functions, the table would need to be 4-bits wide for a total RAM size of 32K. Since 64K RAM is a standard, 2 data input bits can be processed in each RAM. In this case more modes can be supported as discussed below.

2/bit cosine/sine wave

A 2-bit cosine function using binary values 0, 1, 2 and 3 to represent levels –1.5, -0.5, 0.5 and 1.5 has a voltage efficiency (square root of power in fundamental divided by the total power in all harmonics) of 0.979 (2.1% loss) at the optimum transition phase of 55.33º (see figure). For comparison, a 1-bit cosine or square wave has a voltage efficiency of 0.90. With the 2-bit trig functions, the worst harmonic (the 3rd) is –20 dB compared with –9 dB for the square wave. Better performance could be achieved using 4-bit functions which can be supported using 2 extractors per tone.

Sampler threshold counts, 4- and 1-bit modes

The use of a 64K RAM allows sampler states to be counted by selecting both the "sign" and "magnitude" bits as input and loading a table in memory which sorts the 4 inputs to the 4 counters. Another useful mode which can be supported with this scheme is 4-bit sine and cosine functions operating on a single input. In this case, 4 extractors (16 counters) would be needed to perform tone extraction on 2-bit data with

4-bit sine and cosine functions. Another mode is the use of 1-bit sine and cosine (square waves) to extract two tones per extractor RAM.

Summary of characteristics

Tone Frequencies:	D.C. to 16 MHz in 10 KHz steps
Loss:	2.1% in voltage (4.2% in power) for 2-bit sin/cos mode
Highest Sidelobe:	-20 dB for 2-bit sin/cos mode
Other Modes:	1-bit, 4-bit sin/cos, threshold counts (see text)

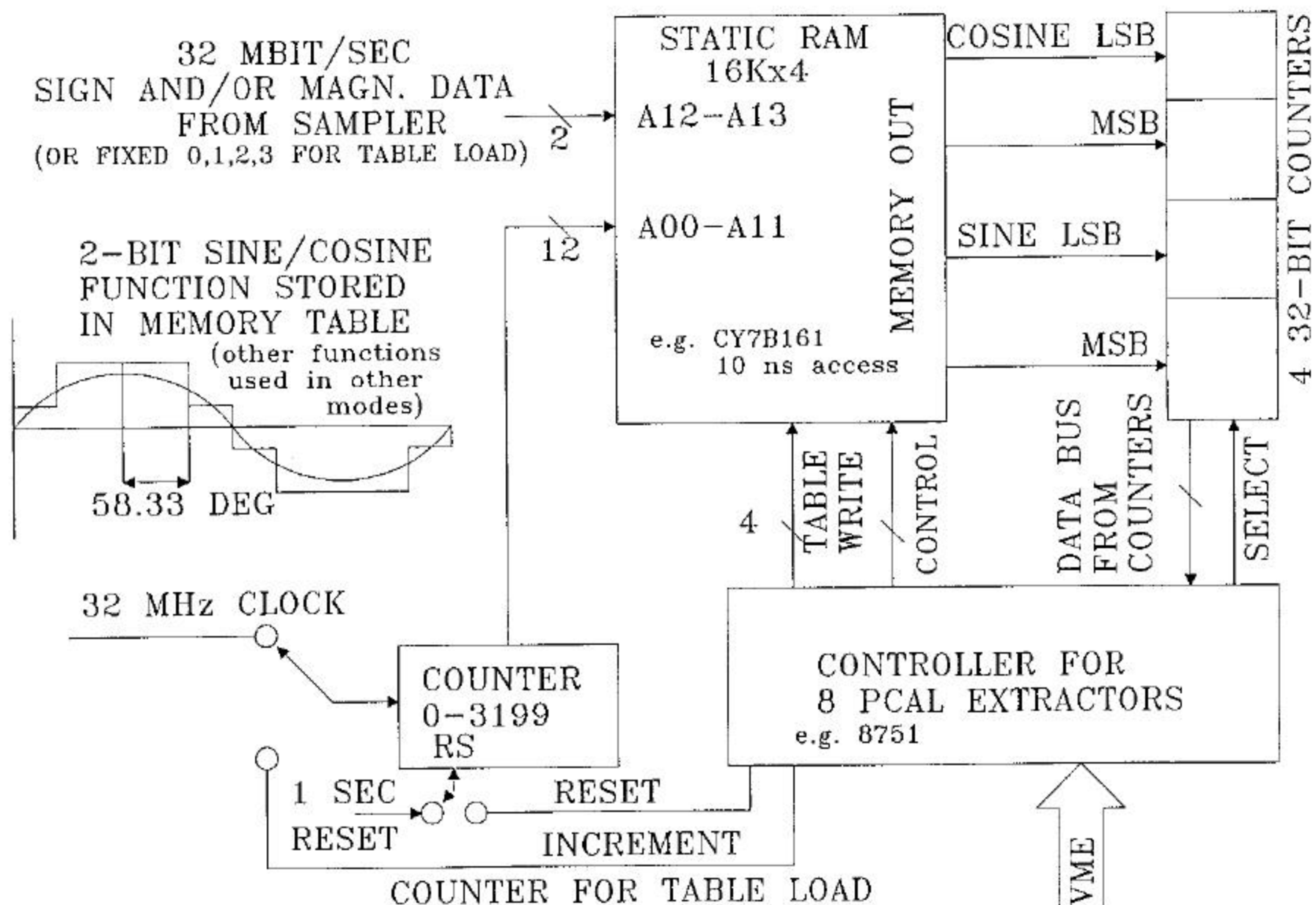The algorithm has been tested in a software emulation and found to yield the expected performance.

FIGURE   BLOCK DIAGRAM OF PCAL EXTRACTOR