EDITORIAL

Thanks for the Memory!

George Fox Lang, Associate Editor

I recently had a pleasant conversation about dynamic instrumentation with one of our contributors, a new engineering professor. I had taken umbrage to a comment made in his otherwise stellar manuscript about the performance of early real-time FFT analyzers and why they processed data as they did. His (first-draft) phrasing suggested that processing the analog signal to an averaged spectrum in real time was a compromise, a second-rate solution compared with retaining a digital image of the sampled input time history.

Having joined the team that produced the first (1957) time-compression real time analyzer (RTA) just in time to see them launch the first hardware-base FFT instrument in 1972, I knew how hard our designers worked to achieve good audio-frequency spectrum processing to a real-time bandwidth of 10 kHz. These were state-of-the-art machines that required the latest components available and pushed them to the extremes of their performance envelopes. There were no compromises in their designs; producing these machines was the electronic equivalent of breaking the sound barrier. In mid-conversation, I suddenly realized this bright young man simply grew up in a world filled with inexpensive memory.

As any graying man or woman will tell you, memory is priceless, and it becomes more cherished with every passing day! I'm old enough that I did not always have a laptop in my book bag nor a PDA in my pocket. In fact, when I entered college in 1961, I went armed with the finest piece of modern personal calculating gear available. It cost me about $25 and had two "bits" of memory: the location of the cursor and position of the slide. I still have that Post Versalog® and its hardbound instruction book. Based on my bamboo-cored slide rule, I would place 1961 memory cost at about $100/*byte* (one byte being eight bits). Calculators of the era were *mechanical* desk-top machines that did little but add or subtract. The most advanced of these were motor-powered. Computers (your choice of analog or digital) were strictly corporate possessions; no one owned a personal computer.

Five years later I earned the right to "punch cards" for Sikorsky Aircraft's digital computer complex, a multimillion-dollar pair of Univac 1108s sharing a mammoth 100 kilobyte memory bank and a roomful of tape drives. It was amazing how much computation you could cause to happen overnight. It was also amazing how many nights your three-foot drawer-full of Hollerith cards could lead to nothing but a few sheets of 11×17 fan-fold paper with a cryptic message such as, "Fatal JCL error

A classic instrument: the Nicolet (formerly Federal) Scientific Corporation model OF-400B.

243, run terminated." Such was computer performance at about $10/byte. We didn't even bother trying to run dynamic signals through them!

The late '60s and early '70s found me at the Noise and Vibration Laboratory (NVL) at General Motors Proving Ground (GMPG). We had five *analog* computers and one *hybrid* model manufactured by the ingenious people at Electronic Associates of Long Branch, NJ. These were marvelous simulation and signal processing tools. We often used them in concert with real hardware on the lab floor below us to solve a broad range of dynamic issues. The "Grounds" also owned an early IBM 360/44 system in the basement of the adjacent administration building. This was updated so often that we joked that the place was actually the IBM Proving Ground.

GMPG was one of the first locations to install Time-Share Option (TSO), enabling programmers to work interactively through "glass screens" instead of punch cards and waiting for printed output. NVL designed and built a lot of custom instruments to suffice its work in that era. My boss, Tom Harris, always designed the most sophisticated of these. It was Tom who broke the news that memory had finally reached the $1/byte level when he posted an *EE Times* headline, "Buy two bits of memory for two-bits."

Shortly after the buck-a-byte barrier had been broken, I joined Federal Scientific Corporation. They were in the final throes of completing the OF-400, their first FFT analyzer. It was an impressive machine in size, weight, line-power draw, *and* in performance. It absorbed two analog inputs and digitized them at 12-bit precision after passing them through phase-matched (to 1°)

120 dB/octave anti-aliasing filters with (1, 2, 5 pattern) bandwidths from 10 to 100 kHz. These data streams were then transformed to spectra using a variable (power-of-two) transform size of 64 to 2048 time points resulting in 25 to 800 frequency-line spectra. The dedicated hardware provided "tri-power" averaging of two power spectra and the cross spectrum and offered all pertinent resulting spectra including the transfer function and coherence in a wide variety of display formats.

All of this was accomplished to a real-time bandwidth of over 10 kHz. Single-channel operation could provide an 800-line power spectral density (PSD) in real time to 20 kHz. This was a "no compromises ever considered" signal processor. At $1/byte, it would have cost up to $6,144 per frame averaged just to store the time data. If you wanted to store enough time-samples to assure that two 800-line PSDs were valid within ±1 dB (≈32 averages), you would need some $197,000 worth of 1972 memory chips. That really makes the near $40,000 price of the OF-400 signal processing system quite a bargain, doesn't it? It certainly makes the point that the design was not a "second-best" compromise; it was a successful first-rate frontal assault on the physical limitations of dynamic measurements. I was proud of it then and I remain proud of it now.

While penning these words, I found myself humming *Thanks for the Memory*. This, of course, was a variation of the long-time theme song of a true American hero, the quintessential comedian, Bob Hope. Hope was born Leslie Towns Hope in Eltham (London) England. He emigrated to America with his family in 1907 and became a U.S. citizen in 1920.

Throughout his adult life he repeatedly placed himself in harm's way to entertain our troops overseas. He did this in WW II, the Korean conflict, the Vietnam War and Operation Desert Shield. Love his comedy or hate it, share his politics or oppose them, you must respect this man's courage and his unfaltering dedication to his nation through the best and worst of times. **S|V**

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A classic centenarian: Bob Hope, American patriot (May 29, 1903 - July 27, 2003).