Guest Editorial

Is analog circuit design dead?

Is this the fate of oscilloscopes *whose innards are controlled by knobs instead of microprocessors?*

Jim Williams, National Semiconductor Corp

Rumor has it that analog circuit design is dead (see EDN, May 13, pg 103, for example). Indeed, it is widely reported and accepted that *rigor mortis* has set in. Precious filters, integrators and the like seem to have been buried beneath an avalanche of μPs, ROMs, RAMs and bits and bytes. As some analog people see it (peering out from behind their barricades), a digital monster has been turned loose, destroying the elegance of continuous functions with a blitzing array of ungainly flipping and flopping waveforms. The recent introduction of a "computerized" oscilloscope—that most analog of all instruments—with *no knobs* would seem to be the *coup de grace.*

These events have produced some bizarre behavior. It has been kindly suggested, for instance, that the few remaining analog types be rounded up and protected as an endangered species. Colleges and universities offer few analog design courses. And some localities have defined copies of Korn and Korn publications, the *Philbrick Applications Manual* and the *Linear Applications Handbook* as pornographic material, to be kept away from engineering students' innocent and impressionable minds. Sadly, a few well-known practitioners of the art are slipping across the border (James E Solomon has stated, for example, that "all classical analog techniques are dead"), while more principled ones are simply leaving town.

Can all this be happening? Is it really so? Is analog dead? Or has the hysteria of the moment given rise to exaggeration and distorted judgment?

To answer these questions with any degree of intelligence and sensitivity, it is necessary to consult history. And to start this process, you must examine the patient's body.

Analog circuit design is described using terms such as subtractor, integrator, differentiator and summing junction. These mathematical operations are performed by that pillar of analoggery, the operational amplifier. The use of an amplifier as a computing tool is not entirely obvious and was first investigated before the Second World War. Practical "computing amplifiers" found their first real niche inside electronic analog computers (as opposed to mechanical analog computers, eg, the Norden bombsight or Bush's Differential Analyzer), which were developed in the late '40s and '50s. These machines were, by current standards, monstrous assemblages made up of large numbers of amplifiers that could be programmed to integrate, sum, differentiate and perform a host of mathematical operations. Individual amplifiers performed singular functions, but complex operations were performed when all the amplifiers were interconnected in any desired configuration.

The analog computer's forte was its ability to model or simulate events. Analog computers did not die out because analog simulations are no longer useful, or do not approximate truth; rather, the rise of digital machines made it enticingly easy to use digital fakery to *simulate the simulations.*

As digital systems came on line in the late '50s and early '60s, a protracted and brutally partisan dispute (some recall it as more of a war) arose between the analog and digital camps. Digital methods offered high precision at the cost of circuit complexity. The analog way achieved sophisticated results at lower accuracy and with comparatively simple circuit configurations. One good op amp (eight transistors) could do the work of a hundred digitally configured 2N404s. It seemed that digital circuitry was an accurate but inelegant and overcomplex albatross. Digital types insisted that analog techniques could never achieve any significant accuracy, regardless of how adept they were at modeling and simulating real systems.

This battle was not without its editorializing. One elequent speaker was George A Philbrick, a decided analog man, who wrote in 1963 (in *The Lightning Empiricist,* Volume II, No 4, October, "Analogs Yesterday, Today and Tomorrow," pgs 3-8), "In modest applications to on-line measurement and data processing, it is quite generally conceded that the advantage of continuous analog apparatus make it irresistible. This is partly owing to the simplicity

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and speed which its continuity makes possible, and partly to the fact that almost every input transducer is also "analog" in character, that is to say, continuous in excursion and time."

However, Philbrick, a brilliant man, was aware enough to see that digital had at least some place in the lab: "Only the most hard-shelled of analog champions would suggest that all simulative and computational equipment be undiluted by numerical or logical adjuncts."

He continued by noting that, "Some analog men, perhaps overfond and defensive as regards continuous functions, really believe that analog operations are generalizations of digital ones, or that conversely digital operations are special cases of analog ones. What can be done with such people?"

"While it is agreed that analog and digital techniques will increasingly cross-fertilize and interrelate," Philbrick concluded, "it is predicted that the controversy between their camps will rage on, good natured but unabated, for years to come in spite of hybrid attachments."

Although Philbrick and others were intelligent enough to prevent their analog passion from obscuring their reasoning powers, they could not possibly see what was coming in a very few years.

Jack Kilby built his IC in 1958. By the middle '60s, RTL and DTL came into common use.

While almost everyone agreed that digital approximations weren't as elegant as "the real thing," they were becoming eminently workable, increasingly inexpensive and physically more compactable. With their computing business slipping away, the analog people pulled their amplifiers out of the computers, threw the racks away and scurried into the measurement and control business. (For a nostalgic, if not tearful, look at analog computers at the zenith of their glory, read *A Palimpsest on the Electronic Analog Art*, H M Paynter, editor.)

If you have read thoughtfully to this point, it should be obvious that analog is not dead, rather just badly shaken and overshadowed in the aftermath of the war. Although measurement and control are certainly still around, the really glamorous and publicized territory has been staked out by the digital troops for some time. Hard-core guerrilla resistance to this state of affairs, while heroic, is guaranteed suicide. To stay alive, and even prosper, calls for skillful bargaining based on thorough analysis of the competition's need.

The understanding that analog is *not* dead lies in two key observations. First, to do any useful work, the digital world requires information to perform its operations upon. This information must come from something loosely referred to as "the real world." Deleting quantuum mechanics, the "real world" is analog. Supermarket scales, automobile engines, blast furnaces and the human body are all examples of systems that furnish the analog information that the silicon abacus requires to justify its existence. So long as transduction remains analog in nature, the conversion process will be required.

A further observation is that many μPs are being used not to replace but to *enhance* a fundamentally analog measurement or process. The current spate of microprocessor-controlled 6-digit DVMs furnishes one good example; others include digital storage scopes and smart thermometers.

If one insists on bringing ego into the arena, the digital devotee will argue that the analog content of these things is an unfortunate nuisance that must be tolerated. The analog aficionado, if permitted to speak, will counter that digital techniques exist only to aid in getting a better grip on a fundamentally analog existence. The question of who is most correct is subject to endless debate and is not really germane.

The point is that although analog is not dead, its remaining practitioners must be more system creatures and less circuit addicts. To be sure, circuits are required to build systems, but analog technicians can only make themselves indispensable in a digital world by their recognized ability to supply what it needs to accomplish its mission.

That this is the case can be easily proven. Consider the effect on the major digital powers of a complete embargo of data converters and signal-conditioning components by the small analog nations. How can a supermarket scale compute the cost of goods it can't get weight information on? Of what use is a process controller without inputs or outputs? Think of the long lines of microprocessors waiting at distributors for what few DIPs of analog I/O might still be available! Imagine rationing of instrumentation amplifiers and V/F converters and alternate D/A and A/D days.

Analoggers can stay very much alive *and need not leave town.*

So it seems that analog is not so dead after all, but really playing possum. By occupying this position, analoggers will stay healthy, very much alive and need not leave town.

An uneasy but workable harmony has thus been negotiated with the dominating numerical nemesis. This compromise is not optimal, but it's certainly a more desirable and useful existence than being dead and is worthy of praise and respect by everyone.

Do all you bit pushers out there get the message?