Are We Teaching the Right Subjects in AAS Degree Electronics Technology Programs?

By

Louis E. Frenzel Jr.
lfrenzel@sbcglobal.net
Technology Editor, Electronic Design Magazine
Adjunct Professor, Austin Community College

Abstract: Given the advanced state of electronics technology in industry and the jobs available to AAS graduates today, there is mounting evidence that community colleges are not teaching the most relevant subjects. Most programs were developed decades ago and offer knowledge and practice skewed from the real needs of industry. This article discusses this gap and makes suggestions for bringing electronic AAS degree programs into the 21st century.

I. A Homogeneous but Out of Touch Curriculum

Most AAS degree programs in electronic technology have their roots in those engineering technician programs developed for technical institutes in the 1950's and 1960's. Others followed in the 1970's with a peak in community college offerings occurring sometime in the 1980's. These programs are fairly homogeneous in that they are structured to include some basic math and physics followed by DC and AC circuits, electronic components and basic circuits, digital, microcomputers then one or more specialty courses in industrial control, wireless, networking, or manufacturing.

Virtually all of these programs were originally designed to train engineering technicians, those employees who work for and assist engineers in the design of equipment. At one time, it took several techs to support an engineer in the various prototyping and testing activities required. Today, that model is no longer relevant. Most engineering technician positions have gradually faded away thanks to developments like large scale integrated circuits, electronic design automation and simulation software, and other computer assists. Extensive simulation and canned designs reduce the number of prototype builds. What little prototyping and testing needed is most often done by the engineer in addition to the design and analysis. While some engineering tech positions still exist in small numbers, these are mostly in research and development environments rather than in industry product design. What this means is that the community colleges are essentially teaching a program designed to train engineering technicians of the past rather than for the actual technician jobs available in industry. The subjects and approach target jobs that essentially are no longer available.

Another issue is that many of the significant changes in electronic technology occurring since the programs were developed have not been incorporated into existing courses or if they have the inclusion is insufficient or out of context. Some examples include DSP, switch-mode power supplies, switching amplifiers, and a systems perspective of electronics. Another lingering problem is the continued overemphasis on bipolar transistors when MOSFETs now dominate all circuit categories. Over 95% of all circuits use MOSFETs while over 95% of the instruction is still bipolar related. The course content and curriculum is skewed from how things really are. This makes the programs dated and not truly focused on the currently offered jobs. Since most programs are accredited, the quality of instruction is satisfactory; however, the content is just enough off base as to be disturbing to industry.

All of this has come clear to me over the past years as I left a full time position teaching electronics technology at a public community college. My position in industry has given me the opportunity to see first hand the trends in components, equipment, design and service practices and the applications of electronics. And it has given me the opportunity to visit companies, talk extensively with engineers, executives, and hiring managers while surveying the available jobs, and seeing first hand how products are designed, manufactured and serviced. What I have witnessed is different to a great degree with what is being taught and how it is being taught. It is a very disturbing trend that has those who hire technicians concerned. And the dated programs may be at the heart of the continuing declining enrollment in electronic technology programs over the past five years or so. It is time to take a serious look at this problem and revise programs to bring them into alignment with how things are today.

II. Technician Jobs Today

To revise and update courses and curricula it is critically important to survey the available jobs first and adjust the content to match. While such a study is a challenging task, it is an essential assignment for electronic departments to ensure their continued viability locally. Here is a summary of what you are likely to discover.

* Few engineering technician jobs. No, these positions have not disappeared completely. Some companies still employ a few in selected projects but in general the whole design process is different today. These positions do require more analysis and design that other technician positions, but with a declining number of jobs there is some question about the need for such in-depth more engineering-like instruction.

* Most technician jobs involve installation, service, repair, operation, testing and measuring, and manufacturing. Despite the years of gloom and doom we hear about manufacturing moving offshore, the good news that much of it has not. There truly are technician level manufacturing jobs available especially in the testing and measuring activities. Otherwise, most technician jobs involve installing new equipment, maintaining equipment, servicing equipment, and repairing equipment. Amazingly, most of the available jobs are not in the electronic industry. They are more often than not in any field where electronics is used rather than developed. Electronics is widely used in industrial control, food processing, manufacturing, chemical plants, transportation industries (trains, planes, etc), automotive, medical, and consumer electronics to name a few.

* Technician repair, service and maintenance jobs have also declined in number because of the increased reliability of IC based products. All products today are based one or more embedded controllers surrounded by other complex ICs that package virtually all of the electronic functions making their repair and replacement difficult if not impossible. Furthermore, the economics of repairing low cost electronic items clearly indicates that it is frequently cheaper to discard a broken product and buy a new and more up to date model. This throw-away approach to electronic equipment has made repair shops and even many repair depots a thing of the past. Of course, large expensive equipment such as MRI machines, semiconductor manufacturing tools like etchers, CVD and photo lithography steppers, and large industrial machines are still repaired and serviced.

* Most technicians now work at the systems level rather than the component level. This means that they work with equipment by simply connecting one "box" to another and testing for proper operation. Repairs are more often than not just the replacement of boards or modules rather than components or even ICs. Little or no circuit analysis is ever needed. There is even strong evidence that an in depth knowledge of electronics is not needed for many electronic technician jobs as borne out by the extensive experience of PC and TV manufacturers and service companies.

* More and more technician work involves a greater need for computer and software knowledge. Most schools provide some basic education in PC operation and software and perhaps even networking. However, education in embedded controllers, interfacing and software is minimal mainly because of the severe lack of time in a two-year curriculum.

Given these general trends, it seems logical to modify and redirect the curriculum and course content to better match the available jobs.

III. Salvaging the Existing Courses and Curriculum

The structure of the current curriculum is still viable and can be revised and updated by changing the content of the courses and adding new courses as needed. Here is a summary of how some of the courses can be updated to bring them into line with current practices.

DC/AC - These core courses are still absolutely necessary as they form the foundation of all of the more advanced courses. However, there are several changes that can better reposition them for technician work today.

* Less math and circuit analysis. Technicians do not design nor do they do any extensive circuit analysis. This makes topics like mesh and nodal analysis truly unnecessary. Thevenin's theorem is still a key knowledge component. A non-mathematical or minimally mathematical version of Fourier theory is truly useful. Other more detailed analysis techniques, AC or DC, are simply outside the realm of real technician work.
* More emphasis on practical topics most technicians need such as wiring and cabling, AC power distribution, dealing with surface mount components.
* One key trend in electronics programs is the combining of DC and AC into a single course while implementing some of the suggestions above.

Electronic Components and Circuits - This is a course that probably needs more revision than any of the others. Here is a summary of topics to be covered or deleted.

* Shift emphasis to MOSFETs rather than bipolar. Over 95% of all transistors in use in modern equipment are MOSFETs. Bipolars still exist of course but mainly in older equipment, linear ICs, and in modern microwave equipment in the form of SiGe or HBT devices. Most courses start with bipolars then go one to include highly detailed BJT biasing, circuits, and applications. JFETs and MOSFETs are usually taught as an after thought. The emphasis is clearly all wrong. While it is essential to understand the operation of a BJT, it is not necessary to understand biasing details to any degree. No one, even most engineers, ever design a bias network for a BJT. Yet, courses are full with that kind of circuit analysis and design.
* Focus on ICs rather than discrete circuits. Virtually all electronic circuitry today is inside an IC. Some discrete circuits are still used but primarily in high power or high voltage applications. While

most current courses do cover op amps, greater emphasis needs to be on wide range of ICs and how they are used.

Linear Circuits - This course may be a separate one or combined with the components and circuits course mentioned above. In either case, most courses still concentrate on discrete component circuits with bipolar transistors when most circuits are digital and MOSFET-based. Here are some suggestions for needed changes and additions based on industry publications content and engineer interviews.

- Greater emphasis on switch-mode power supplies which now dominate the power supply market. Most products today use a switcher in the form of a switching regulator or DC-DC converter. Inverters are also widely used. Coverage should also consider the more modern bus architecture now used by most products and the widespread use of power management.

- More emphasis on ICs rather than discrete circuits. Op amps and their applications dominate, but there are so many other ICs such as video and audio amplifiers, switching power amplifiers, programmable gain amplifiers and others.

- An update of the analog-to-digital and digital-to-analog converter coverage. These devices are in most equipment today. Existing courses still focus on the older R-2R DACs and successive approximations ADCs while in terms of actual usage switched capacitor ADCs and DACs, flash converters, pipelined converters and sigma-delta converters dominate the applications.

- More or better coverage of phase-locked loops (PLLs). This is another widely used circuit that is given limited coverage if any in most courses. Frequency synthesis is another critical offshoot of this technology that shows up in so many applications today.

Digital - Most digital courses still focus on the older TTL and CMOS small scale logic which is rarely used today. Those older technologies do of course provide a convenient frame work to teach digital logic, but students may get the wrong impression about how real digital equipment is made. Today, most digital functions are implemented by an embedded controller. These cheap, single chip devices can be programmed to do any thing that the older discrete logic circuits do. And they can serve multiple purposes. Programmable logic devices (PLDs) are the next most commonly used digital devices. These show up as PALs, GALs, complex PLDs, FPGAs, ASICs, and other devices. Luckily, most digital courses at least offer an introduction to PLDs these days. Discrete logic is a distant third when it comes to implementing digital equipment. It shows up mainly in older designs and in newer designs as bus line drivers and receivers and various interface related components. Karnaugh maps, while still widely taught, are rarely used any more in practice.

Microcomputers - All two-year programs offer an embedded controller course. This is essential because all, yes all, electronic equipment today contains at least one embedded controller and often two, three or more. Such courses should delve deeper into operation, programming, interfacing and applications. It is also essential to introduce DSP. Most DSP is by way of a special embedded controller. It is not necessary to teach the mathematical background of DSP but it is easy to teach the concepts. Most new equipment contains DSP today including all cell phones, PCs and laptops, CD and DVD players, MP3 players, networking equipment and almost any thing else you can think of.

A Systems Perspective - Missing completely is a course or other coverage of how electronic equipment and systems are designed and serviced today. Most technician work is at the systems level whether it is servicing a large complex product with multiple subsystems or testing a completely self contained system like a cell phone to some international standard. The basic system tool is signal flow in a block diagram. Students need to learn the types of circuits and their function at the block level as they actually manifest themselves in real equipment. One approach to this problem is a separate systems course or teaching systems content to some extent in all courses. Regardless of the method, it is a key missing ingredient in electronic programs today. Teach more systems and fewer circuits. It is not something most faculties will like or adapt to but it is the way of electronics today.

A huge part of the problem lies with the textbooks which are typically behind the times. The deficiencies mentioned above can be seen in even the most recent editions of popular textbooks. Since faculty usually teaches from the text, a dated text will produce a dated course. Furthermore, texts are written by faculty who in general do not have recent industry knowledge, experience or perspective. Since publishers rarely ask industry for input, the problem is perpetuated. The great hope is that faculty will stay current and include new material in their courses. Some do, many do not.

Some justification for the recommendations above can be seen in a program funded several years ago by the National Science Foundation. Called the Work-Ready Electronics program, the project identified key omissions and dated content in electronic technology textbooks. Most of the deficiencies were those identified for each course above. The project based at the Maricopa Advanced Technology Education Center (MATEC) in Tempe, AZ, implemented a program to develop online tutorials that can be used to update existing courses and provide faculty continuing education. As many as 25 modules are expected to be available by the end of 2006. For details, go to, www.work-readyelectronics.org.

IV. Resolving the Associate to Bachelors Transfer Problem

If AAS electronic technician programs are changed and updated to better match the technician jobs of today, what will happen if a student wants to transfer to four-year bachelors degree program in electronics? Minimizing the math and eliminating much of the circuit analysis and related design material will make it more difficult for the four-year schools to accept transfers. As some faculty I have talked with say about this proposal, we would be just dumbing down the program. A better way to view it is adapting to the ever changing technology and industry needs. Isn't it better to teach what is current and needed rather than the history of electronics which is what the current curriculum largely is?

Today as in the past, AAS programs are designed to educate engineering technicians who can in the future transfer to four-year technology programs for a bachelor's degree in technology. That is an ideal scenario and some do take that route. (That is how I got my degrees. I obtained an AAS degree then worked in industry for a while then transferred to a university and eventually got my bachelors in technology degree.) While such a path is highly valuable, it is not one that is as common as one would think. Few if any statistics are available to indicate what percentage of AAS degree graduates go on for a BSET, but it is estimated from discussions with many department heads and administrators that the percentage nationwide is probably less than 5%, if that. The figure is higher in those areas where a university offering a BSET is available to community college AAS graduates, but even then it is probably no more than 25%. Most AAS graduates want to go to work sooner so opt for a job rather than more education. For this reason, little is lost if the curriculum is changed to better fit the new technician jobs now being offered. Yet, many in academia will be severely distressed by losing this option. We all want a student to be able to go on to higher levels of education without having to start over. Some of those routes are already available at universities with programs that accept AAS transfers but go on to award, not a bachelors of science in technology, but in applied science, management, manufacturing, or some allied topic.

Finally, BSET grads are really engineers anyway. In my own experience, as a bachelor of technology graduate and as a hiring manager for many years, I have seen most BSET graduates get jobs as engineers. Looking at and comparing most BSET and BSEE programs, they appear more similar than not. They all demand the heavy math-science background and most of the courses in the technical specialties use the same textbooks. True there are differences, primarily a more applied, hands on approach is taken with the BSET program where BSEE programs stress more design and analysis. Why not just dub the BSET graduates as applied engineers and be done with it. Forget the dated and flawed notion of the mythical technologist. Have you or anyone else ever seen a job ad for a technologist? Of course not. The jobs are technician or engineer. Structure programs to match the model that industry uses.