A SHORT HISTORY OF PACKAGED POWER SUPPLIES

Nowadays, we electronics people tend to take packaged power supplies for granted — whether they're benchtop units with variable outputs for powering experimental circuits in a lab, remotely programmable units under computer control for automatic equipment testing, or the compact modules built into a wide range of equipment. But it wasn't always this way, as the author of this article explains. Currently Sales Manager of leading power supply maker Kepco Inc., he's been in the power supply industry for 35 years and has seen it evolve from very humble beginnings.

by FRANK TOICH

The power supply industry dates back to the early 1920s, when crude devices were first developed to serve as 'B' battery eliminators, to power radios in both the commercial and consumer markets.

The market for separate receiver power supplies evaporated around 1929, when most radios manufactured included a built-in power supply. The need for stand-alone power supplies remained relatively small in the 1930s and into the 1940s. The dominant technology during this period consisted of vacuum tube linear regulators.

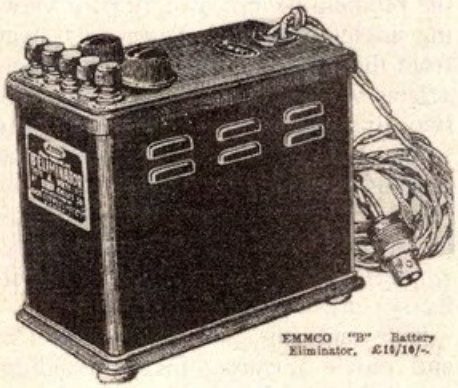
Power supplies used vacuum tubes for both the power and control elements. Typically, a voltage regulator (VR) tube, the forerunner of today's zener diodes, was used to produce a stable reference. Control was pretty much limited to the manual twisting of knobs.

In those days we did not care too much about dissipation. Under normal circumstances, vacuum tubes ran pretty hot — and unless the plate of the tubes glowed red, or glass started to melt, no one worried much about it.

In the mid 1940s, three companies set up shop in a relatively obscure community in Queens, New York. These companies, who eventually became leaders in the industry, were Lambda, Sorenson and Kepco. While all three companies exist today, only Kepco maintains its independence and original ownership and continues to operate out of Queens, New York.

A milestone in the industry occurred in the 1950s, when semiconductors were first introduced into the power supply design. As semiconductor designs proliferated in the market, with transistors replacing tubes, concerns about dissipation and heat dominated the thinking of power supply designers. Germanium transistors did not have the ability to glow in the dark, as did tubes — they simply melted and quit. Designers of these products suddenly had to take their thermodynamics seriously.

Products using transistors were limited to low voltage models at modest power levels, or hybrid designs which used semiconductors in the control circuit and vacuum tubes in the power stage to make possible higher voltage products. In the 1950s, and early 1960s, power supply products adopting Mag-Amp (magnetic amplifier) technology satisfied those applications requiring substantially higher power.



(Above) The first mains power supplies appeared back in the 1920's, advertised as 'B-Battery Eliminators'. This one was advertised in 1927, in Australia's Wireless Weekly.

(Below) Kepco's first power supply, the Model 103 Triple Output Vacuum Tube unit — made originally to power experimental valve circuits for universities and colleges.

This same time period also brought us the concept of the first remotely programmable power supplies. A pioneer in this field was Dr Kenneth Kupferberg, one of the founders of Kepco, who in his career was credited with 14 patents.

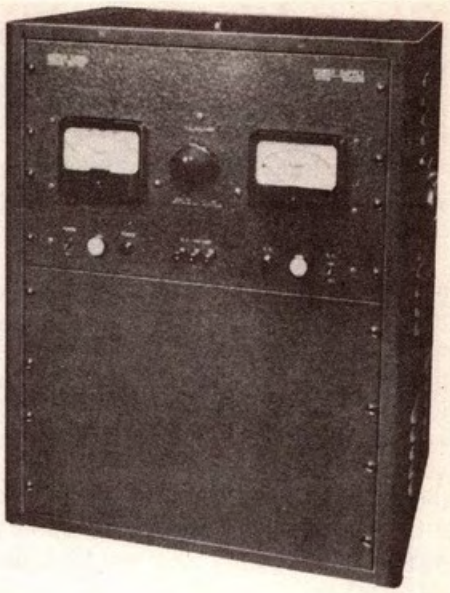
In the 1960s, the world was still analog. Computers were still in their early phase of development. The big debate focused on analog computing (op-amp control for simulation and modeling), and that strange concept called digital computing.

In this time frame, linear series-pass power supplies were seen more as power amplifiers than a power source. This amplifier concept exploited the high gain and linearity of the transistors and created what were, in effect, high power operational amplifiers.

As op-amps, they were made to scale, sum, integrate, or manipulate signals. To accomplish this, power supplies were being produced which allowed access to all of the control nodes. Both input and feedback control elements could be removed and substituted by the user, to permit manipulation of the output to satisfy many diverse applications.

The 1960s also saw the introduction of true bipolar (four quadrant) source/sink units, and the concept of ferroresonance for correction of source voltage variation in a highly reliable, low parts count package.

In the 1970s, an energy crisis which affected the entire industrial world provided the switching power supply with an opportunity to re-surface and



(Left) The Kepco Type SC , the company's first 'transistorised' power supply. (Centre) The Kepco Type KM, a high power supply using a magnetic-amplifier control system. (Right) The Kepco Model 700, a vacuum tube supply delivering 0-350V DC at up to 750mA.

establish a significant position in the electronic marketplace.

The design and manufacture of switching power supplies can be traced back at least to the 1950s. At that time, these products were produced in huge quantities, mostly to replace vibrators. In those days, vibrators converted an automobile's 12V DC into high voltage DC by mechanically switching the current into a transformer (the first switch-mode power supply)! Later, germanium transistors were used to switch electrically.

The fundamental problem which inhibited the advancement and greater use of this topology was its relatively low frequency range (within the mid-audio spectrum), which caused these products to whistle annoyingly.

The big breakthrough in the 1970s was the development of low-loss ferrite as a transformer core material — coupled with the readily available, higher speed silicon transistors. These made possible the practical reality of high frequency products which could operate above 20kHz, where they were inaudible.

During this same decade, the high gain series-pass linear power supply was enhanced with a new level of intelligence: the ability to follow commands from a host computer via a standard communications bus.

Digital control was being grafted onto the front end of linear power supply products. The very first interfaces consisted of resistor chains that were in parallel with reed relays, to create BCD digital control. Then came digital to analog conversion (DAC) for voltage control, and finally, in mid-decade, the power supply industry adopted the instrumentation bus standard introduced by the Hewlett Packard Company as HPIB. This was adopted as IEEE-488 by the Institute of Electrical and Electronic Engineers, and later renamed GPIB by instrumentation manufacturers. In Europe, this is known as the IEC bus.

Prior to this industry standard, the industry was limited to the RS-232 serial bus which was very slow and restricted to relatively limited distances between controller and instrument.

The 1980s saw many new startup companies enter the market producing switch-mode products. Many of these new companies were based in the Pacific Rim, first in Japan, and eventually shifting to Taiwan and Hong Kong.

During this decade, the quality and performance characteristics for switchers were substantially improved. Operating frequencies also increased from the 25-50kHz range on up to 100kHz and even 1MHz, as FETs replaced bipolar transistors.

So here we are now, more than half way into the 1990s, and we have already experienced numerous developments. For example, this industry, driven by market demands, has produced switching products which operate at increasingly higher frequencies and are constructed using surface mount technology (SMT), substantially reducing their physical size.

We have seen these same products offering such features as wide range input to accommodate source voltages worldwide, active power factor correction to minimize harmonic distortion on power lines, and forced current sharing to provide these products with the capability of fault-tolerant operation.

Modern fault-tolerant power systems typically employ a technique known as parallel N+1 redundancy. The advantage of this method over the traditional paralleling scheme is the ability to distribute power (current sharing) and minimize the stress on individual units. The popularity of the

Kepco Model BOP supplies, which are of the bipolar four-quadrant type and able to sink power as well as source it.

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N+1 redundant system approach with current sharing has increased so rapidly it has become a *de facto* standard in the industry.

Another trend which has enjoyed increased interest is that which is sometimes referred to as point-of-use stabilization; distributing the power at some intermediate voltage such as 48V, 150V or 400V. This technique is also known as 'distributed power'. It relies on the use of a bulk supply to perform the conversion of AC from the mains into DC, which then, in turn, powers any one of a number of lower power DC-DC converters placed directly at the point of load. This technique of power distribution has lowered the system wire count, resulting in more manageable harness sizes — making the products easier to build and reducing their overall size.

Instrumentation power supplies now interface with the IEEE 488.2 bus, support VXI and embrace various 'soft panel' architectures.

What's on the horizon for the next phase of the power supply evolution? Stay tuned!

Our thanks to Len Altman, principal of Kepco's Australian distributor Obiat Pty Ltd, for his help in preparing this article — which was adapted from the publication 'Kepco Currents', with permission. Further information on any of the Kepco range of power supplies is available from Obiat at 129 Queen Street (PO Box 37), Beaconsfield 2014; phone (02) 9698 4111, or fax (02) 9699 9170. ❖

The latest Kepco ABC, a microprocessor controlled 'zero up' switchmode supply that is controllable all the way down to zero output.

Kepco's own story...

I would like to share with you a little of the early history of Kepco, whose 50th anniversary we're celebrating this year.

Just after World War II, my brothers Jack, Jess and Ken and I came together to set up Kepco. Back then, we called it Kepco Laboratories. From our wartime experiences, we had some reasonable expertise in nuclear instrumentation and in all sorts of electronic gear. We were particularly interested in the possibilities for solar energy. We looked at all of these areas to decide what we might want to do and what sorts of equipment we might build.

We decided to address the possibilities for building teaching equipment, where we had some expertise too. This is how we came to design the circuit panel we called Model 103. Students could create some 30-odd circuits on this three-tube panel, using commonly available components. Cardboard overlays guided their construction.

The Model 103 triple-output power supply was designed to power these 30 circuits. It featured a variable B+ (HT) supply for the plates and an adjustable grid-bias 'C' supply and, of course, an AC filament supply.

We had some brochures printed and I mailed copies to the chairman of every physics department, every electrical engineering department and every chemistry department at colleges around the country. We started to sell the panels, but it quickly became apparent that more people were interested in the power supply than in the circuit panel.

We recalled from our days at Los Alamos that there were lots of power supplies used in laboratories, and so we said to ourselves that this was an area where we might contribute. There seemed to be a need.

From then on, we solicited power supply requirements, designed some interesting vacuum tube and magnetic-amplifier products and began to deliver to the academic and industrial communities.

When transistors became practical, Kepco 'transistorized' its power supplies and pioneered such concepts as the programmable power supply and four-quadrant power supply.

In the mid 1970s, Kepco participated in the work of the IEC (International Electrotechnical Commission), writing safety and testing standards for the power supply industry. In that same period, Kepco began to produce IEEE 488 programmable power supplies and the analog instrument gradually became digital.

Today they work with microprocessors, keyboards and you need a password to adjust their calibration. They still work pretty good — which may be why we're celebrating our 50th anniversary.

We're a member of the VXI *plug&play* alliance and produce a wide variety of power supplies that can be linked directly to a VXI controller.

There are hundreds of companies in the power supply business now, a half century after we helped to invent an industry. We're not the largest, but a lot of customers have given us their business over the years and we're delighted to have earned their trust.

— Max Kupferberg, Kepco's General Manager