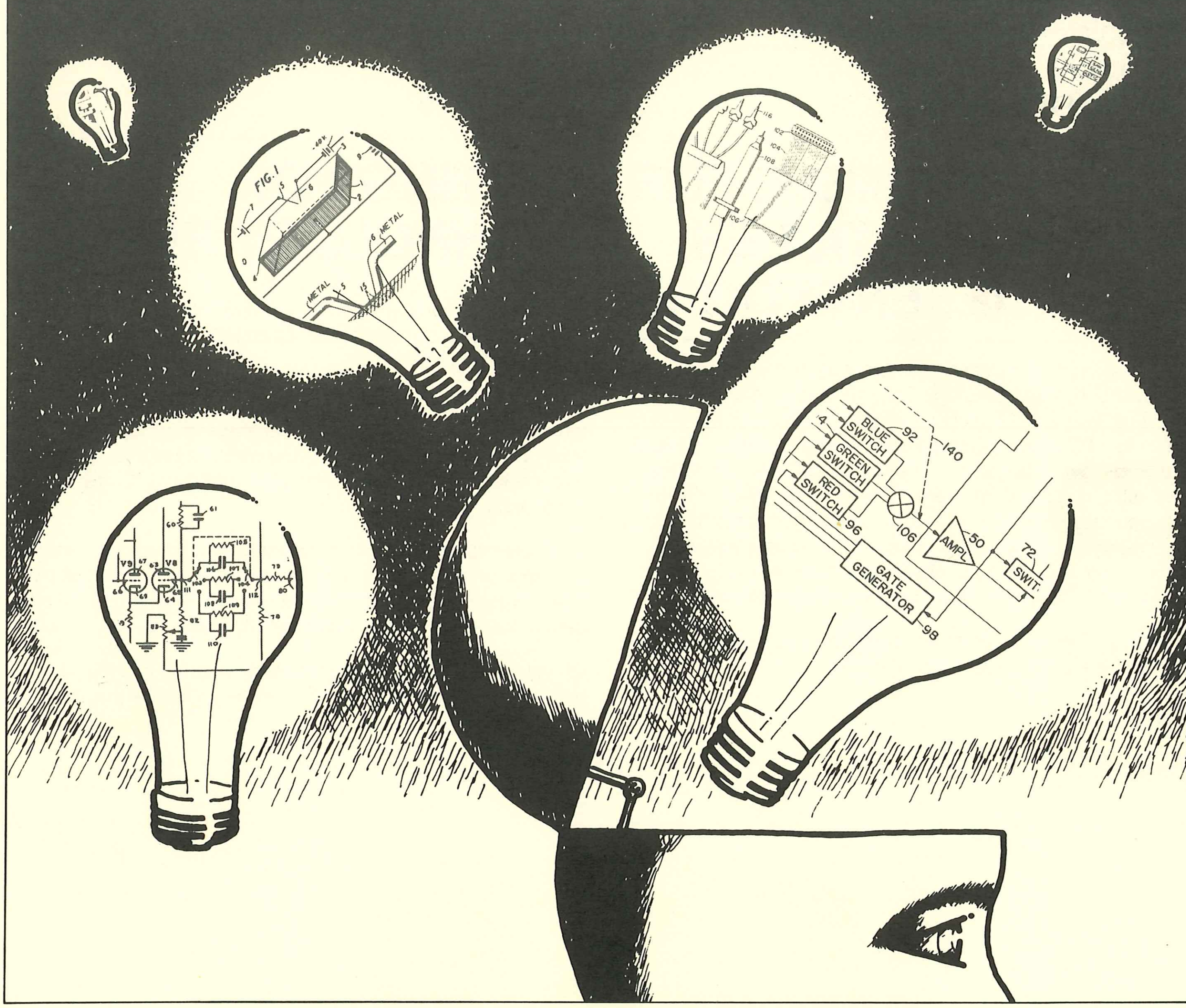
TEK INFORMATION FOR TECHNOLOGISTS

JANUARY 1984

TECHNOLOGY report

COMPANY CONFIDENTIAL

PATENTS



Tektronix®
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Why TR?

Technology Report serves two purposes. Long-range, it promotes the flow of technical information among the diverse segments of the Tektronix engineering and scientific community. Short-range, it publicizes current events (new services available and notice of achievements by members of the technical community).

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WRITING FOR *TECHNOLOGY REPORT*

Technology Report can effectively convey ideas, innovations, services, and background information to the Tektronix technological community.

How long does it take to see an article appear in print? That is a function of many things (the completeness of the input, the review cycle, and the timeliness of the content). But the minimum is four weeks for simple announcements and six to 12 weeks for major technical articles.

The most important step for the contributor is to put the message on paper so we will have something to work with. Don't worry about organization, spelling, and grammar. The editors will take care of that when we put the article into shape for you.

Do you have an article to contribute or an announcement to make? Contact the editor, Art Andersen, 642-8934 (Merlo Road) or write to d.s. 53-077. □

PATENTS:
OR, NOW THAT YOU'VE INVENTED IT, HOW DO YOU PROTECT IT

Patents and the patenting process are ancillary to the art of engineering – but to the *business* of engineering, patenting is one of the fundamentals. This issue of *Technology Report* attempts to cover patents from the perspective of the engineer as a technologist and the perspective of the engineer as a businessperson. Whatever success we've achieved in this attempt is largely due to cooperation of the people in Patents, Trademarks, and Licensing. *Art Andersen, Managing Editor*

Why should an engineer know something about patents? Why should an engineer in a high technology company seek patent protection? The simplest answer to both questions is *it's good business practice.*

Yes, it's good practice, but why?

We live in a competitive, fast moving world where almost anyone can be tempted to copy, usually by reverse engineering. If a patent is broad enough, it can stop such competition cold. Although not all patents are that effective, many patents make "designing around"– that is, alternative engineering approaches undertaken to avoid a patent – time consuming and costly. But this protection is only part of the reason patents are sought, only part of the answer to the question: Why patent?

To answer more fully, we will have to look at the concept of *intellectual property.* Intellectual property encompasses not only patents but trade secrets, copyrights, and trademarks too. These all relate to protecting ideas – that is, products of the intellect. When you "do" engineering, you are either innovating or you are using someone else's innovation. Engineers swim every day in a sea of intellectual property.

The innovative engineer is an asset. Even more valuable are innovative engineers who recognize how broadly applicable their inventions may be . . . and sense the need for protecting the intellectual property they have produced.

This issue will look at some history – patents have a long history – and at some definitions.

Perhaps definitions is the wrong word as law is really interpretation rather than absolute certainty. And, since law does involve interpretation, answers or opinions specific to your questions about intellectual property will have to come from Patents, Trademarks, and Licensing rather than from this issue of *Technology Report,* or from your peers.

■

Because patenting has been practiced for centuries, you may think of patents as passive, and yes, a little old fashioned, sort of like earthwork fortifications in this microchip age. But do you know that for every court battle over a patented technology, there are dozens, even hundreds of patent licensing agreements between companies, even companies in direct competition with one another?

In this cooperation, companies are able to enhance the technological climate they need to prosper. They can let their engineers innovate freely, employing all appropriate technology even if others hold patents in the field. If necessary, use of that technology can be obtained through negotiation and cross licensing. In a high-stakes technological swap meet, patents are trading power. Too few engineers fully realize that the patent is a powerful tool for gaining complementing technology

Thinking of patents as only barriers overlooks much of what patents and patenting are all about. In high technology, the patent can be the glue to join technologies. Rather than just protecting a something we want to feature, a patent can help blend the fruits of other technologies with ours.

If you have the baseball and someone else has the bat, you want to do more than protect your baseball – you want to use it. What do you do? You team up. One of the values of a strong patenting program is that it assures that you can team up and be more than a spectator who happens to own a baseball.

Perhaps it may help to think of patents as a "postprocessing" tool in product development programs. Like a software postprocessor, a patent helps fit the idea, the innovation, to the environment.

Like a fat wallet, a substantial patent portfolio makes for confidence. That confidence is invaluable, perhaps even the "edge." Confidence can mean peaceful relations with competitors. Not just using patents to fence out the copiers, but using them as chips in negotiations – or sometimes as dissuaders. We'd like one kind of competitor to think: "We don't want to mess with Tek, Tek's technology is not only state-of-the-art – it's protected." We'd like other companies to think: "With their technology – and patents – in X, Tek might be open to working with us on Y."

This issue is not a how-to-patent-it piece. Instead, we hope that by discussing some aspects of the broad subject of *intellectual property* protection, we can improve the climate for innovation at Tek.

Intellectual property and intellectual property rights are abstractions, just as the concepts of real property and real-property rights are abstractions. Patent applications, copyright statements, and trademark symbols are public evidence that someone claims rights in a product of the intellect. Patent grants and judicial process confirm or strengthen these claims. Some rights, however can exist without public evidence, trade secrets for example.

In the few minutes you will spend reading this issue, we can only hope to alert you to what can be gained, and what can be lost.

And now, some history.

HISTORY AND CONCEPTS

"The Congress shall have the power to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries." U. S. Constitution, Article 1, Section 8.

This section reviews the history and the basics of patents and what the engineer must do to nail down Tek rights. It also discusses how patentability can be jeopardized and lost.

■

The first "modern" patent was issued in 1421. The foundation of patent law dates even earlier, back almost two millenia to the ancient Greeks. Can such a long-standing device still protect the innovations of the late 20th century?

The answer to that question is yes.

But there are more questions: How much protection, what are the geographic limits, what are the risks? What can be patented, how do you patent, what protection mechanisms besides patents are effective? Before going into these important details, let's look at the historical basis for patents.

The ancient Greeks protected developers of new recipes by granting franchises. Had an ancient Greek created a "Big Mac," for example, he could gain exclusive usage of his creation through a franchise. The Greek concept of reserving benefits to the inventor recognized the importance of innovation.

As the years went by, artisans with technical skills and knowledge became important and even critical to the social fabric of the times. Civil authorities sought to encourage inventiveness by assuring these people an edge in the market. Monopolies were granted, giving the holder a barrier against ordinary competition.

In 1421, the Republic of Florence issued the first recorded patent, granting to the inventor of hoisting gear for unloading marble from barges the privilege of sole use of the product of his intellect. His *intellectual property* was protected for three years, but only as far as the limits of the civic power extended geographically, and, of course, only to the limits of the authorities to police.

In return for protecting the inventor of the hoist, the public received early knowledge of the invention. With this knowledge to build on, improvements would be easier; other inventors would not waste time and money in reinventing the hoist. And after the patent expired, the public also received the rights to use the invention freely. There was a *quid pro quo,* the something-for-something that is essential in the patenting concept. The public learns something useful; in return, the inventor gains a better market position. These fundamentals apply today.

Patents promote invention. They do this by "securing to inventors the fruits of their inventions."

Gutenberg saw his invention, movable type, sweep across Europe, but he didn't clean up financially. Then, as now, the rights granted to inventors were localized within the boundaries of the granting power. Today, patents are still local, recognized nation by nation. And the patent process and extent of the protection in each nation differ in much the same way as cultures, traditions, and laws differ. Designers need to know that patenting processes are far from automatic. Even worse, those processes that are automatic in one jurisdiction may tend to eliminate patentability in some other jurisdiction.

Ideas Are Not Automatically Protected

Inventions are products of the intellect; that's why they are called *intellectual property.* Unlike personal or real property, ideas are not automatically protected by law. If someone stole the first model of your better mousetrap, you could call the police. But if someone copied your unpatented mousetrap-idea – tough.

The procedure for obtaining protection is often misunderstood, but it must be followed or the inventor risks losing the shield of law for his or her ideas. For example, it is natural for engineers to prepare papers and articles describing their achievements. However, the Patents, Trademarks and Licensing department should be informed well before publication so that they can take measures to protect any inventions discussed. If the inventor's ideas are communicated *before protection is sought,* rights in the invention may be jeopardized. That is why premature publication of technological information should concern us all.

And then there is the problem of telling too much by patenting.

Trade Secrets

Because publishing a patent necessarily exposes the idea, more may be lost than gained by patenting some innovations. In such cases, the inventor or the possessor of the intellectual property may choose to keep the idea close to the vest as a *trade secret.*

As the medieval guilds guarded knowledge of processes from outsiders, some companies today guard processes without patenting. They do this when the product as sold might not reveal the manner in which it was made, and thus, the possessor of the process may be able to keep it secret. This can be good strategy for several reasons.

For one thing, a secret may last forever while a US patent is good for only 17 years. And too, the patent itself may convey enough information for a competitor to achieve the same results without using the patented process. Infringement of the patent may be difficult to detect and prove. On the other hand, a secret may be difficult to keep, especially as people change from job to job.

The Patent Process at Tek

At Tektronix, the patenting process begins when an inventor fills out and sends an *Invention Disclosure Form* to the Patent Department. The content of the disclosure form is reviewed by the patent committee for the appropriate group or business unit.

If the committee decides a patent should be sought, the Patent Department prepares a patent application, which is filed in the U.S. Patent and Trademark Office (the PTO), Washington, D.C. The patent application contains a description of the invention, including any alternative implementations, and one or more claims; the claims define the legal "metes and bounds" of the invention.

In time, currently 18 to 24 months, a patent examiner issues an Examiner's Action based on a search of prior art (publications, patents, or other references describing prior relevant work of others).

Claims in the application may be allowed or rejected for any one of several reasons. The usual basis for rejection is that the claimed invention is known or obvious in view of the prior art. The Patent department responds to the Examiner's Action, rebutting the rejection and perhaps amending the claims to avoid the prior art. If all goes well, and it does in most cases, a patent is granted to Tektronix about 30 months after the date of filing and Tek rights in the invention are secured.

The granted patent bears the name of the inventor(s), but is owned by Tektronix. As is true with most corporations, Tektronix employees assign their rights to the company for inventions made on the job, or relating to the company's business whether made on or off the job. The *Employment Agreement* we all signed when we came to work provides for such assignment.

If the inventor's ideas are communicated before protection is sought, the inventor's rights may be jeopardized.

What is Patentable

To gain a patent in the United States, the inventor has to establish *novelty, usefulness, and nonobviousness.* The invention must be *novel* – that is, demonstrably different from all previous work, patented or not. This work is known as *prior art,* and the inventor has the obligation to tell the Patent and Trademark Office about the existence of any relevant prior art.

For purposes of patentability, inventors are assumed to know all of the publically available art relevant to their invention, no matter how obscure it may be. Even though there is no penalty for not knowing all the prior art, it's a good idea to search for it before filing an application.

Temporal priority is also critical in patentabilty. The time of invention, not just the time of patent application, is very important. Here's where the *Invention Record Notebook* comes in. Without acceptable records, you can lose a patent dispute to a later claimant; you may not be able to prove that you invented earlier. A properly maintained and witnessed record such as the *Invention Record Notebook* is universally recognized as the best proof of what was done and when it was done.

For patent purposes, an invention does not occur until it is *reduced to practice* – that is, sufficiently tested to show the invention will work for the intended purpose. Or the invention can be *constructively reduced to practice* by filing the patent application.

Practicality or utility establishes *usefulness,* another must for patentability. Patentable ideas don't have to be commercially desirable or profitable. An invention doesn't even have to be better at something, it just just has to meet the legal definition of utility. A method of converting silicon wafers to sand could have legal utility even though the process would be a commercial bomb.

You can't patent something that is *obvious.* If the way you made an invention work would have been obvious to "someone of ordinary skill in the art," then it's not patentable. For example, the mere substitution of materials or parts probably would not stand up upon patent examination. On the other hand, a *novel* and *nonobvious* use of an old device is patentable.

Patent Types

In the United States, there are three types of patents. Two types, design patents and plant patents, are of little interest to Tektronix. Design patents protect ornamental designs. Plant patents protect asexually developed plants such as hybrid roses. (Sexually reproduced plants are not patentable.) The third type, the utility or "regular" patent, is of great interest.

Five types of inventions can be protected by utility patents:

Process – methods and steps used to produce results.

Machine – a coffee grinder and an electronic circuit are both "machines."

Manufacture – a made object such as a screwdriver or ashtray. (A "machine," in contrast, is dynamic with operating parts.)

Composition of matter – a compound, such a aspirin, or a mixture of ingredients. Some compositions of matter are not patented; they can be guarded as trade secrets.

Improvement – an improvement of something in the preceding classes.

Which one of the five utility types apply to software? That opens a sticky subject.

Can Software be Patented?

The drafters of the US Constitution carefully limited patent protection to the "works of artisans" as opposed to the "theories of philosophers." In principle, this limitation precludes someone from protecting their "rights" to any machine employing a mathematical formula, because formulas are discovered, not made. And, since mathematical formulas are considered to define laws of nature, such formulas lack the essential patent element *novelty.*

However, the limits on patentability do not extend to realizations derived by applying mathematical relationships. A novel antenna invented by applying mathematical relationships probably would be patentable. But a series of steps for converting from one mathematical value to another – for example, from binary to binary-coded decimal – would not. Such a patent grant would essentially forbid anyone from accomplishing the conversion, regardless of the hardware used.

In 1978, the Supreme Court denied a patent for an algorithm to Dale R. Flook *(Parker vs. Flook)* saying, in effect, that arithmetic algorithms defining the steps for solving a mathematical problem were not inventions as defined by statute. Implementing an algorithm, known or unknown previously, did not constitute the type of invention for which a patent could be granted. For legal purposes, all arithmetical algorithms are assumed to be known.

The Parker vs. Flook decision changed the old question: "Are programs patentable?" to a new one: "Are physical processes or systems incorporating arithmetic algorithms patentable?" If the hardware is superficial and the arithmetic algorithm significant, as in *Flook,* it appears no patent will be granted. If the hardware is significant and the mathematical relationship substantially less significant, as in the antenna, there is hope for a patent.

In 1982, the Court of Appeals for the Federal Circuit (CAFC) took jurisdiction from the U.S. district courts over all appeals concerning patent matters. Because the Supreme Court is likely to defer to this new court's expertise in patents and technological matters, a two-part test for patentability most likely will apply in some cases involving software. The test, developed by the Court of Customs and Patent Appeals (the predecessor of the CAFC), is shown in figure 1.

Both figure 1 and the summary of protection mechanisms for computer software (page 7) are adapted from the article "Protecting Software and Firmware Developments" by Lechter, Cushman, Darby, and Cushman; *Computer,* August 1983.

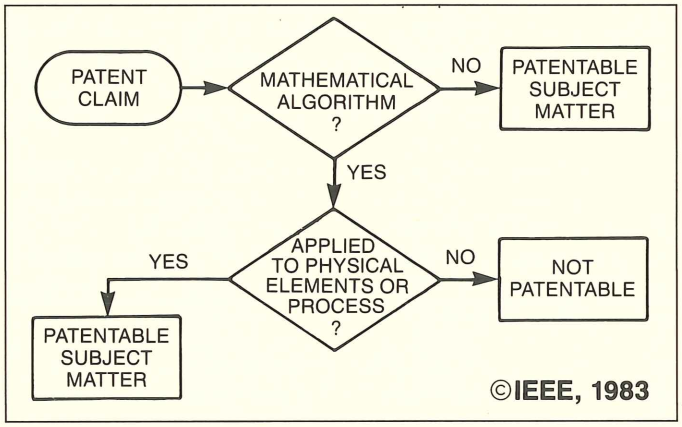

Figure 1. This two-part test is likely to be used to determine patentability where software is involved.

Of What Value is a Patent?

By allowing the patent owner to determine who shall use a patented invention, the owner gains "space" to exploit the invention. The grant of a patent gives the patentee the right to exclude others, but the right must be asserted. Competitors can and do move in; it is up to the patentee to police his patent in whatever way he chooses. This may include legal actions or no action. For example, he may choose to ignore the competition as "small potatoes."

Patents can generate royalty income. In addition, as we described earlier, they can stimulate the trading of ideas and cross licensing between organizations.

This trading may come about because just having a patent for an invention is not always sufficient. The protected technology may stand idle because building a product based on the technology could infringe a patent owned by someone else. An *improvement* patent is often subject to more basic patents that will tie the hands of the holder of the improvement patent. But the improver has something to exchange in a cross-licensing agreement. With such an agreement, or a royalty-based license, the improvement can be exploited.

And to the employee who is an inventor, patents look good on his or her record. They are impressive demonstrations of competence.

Summary of protection mechanisms for computer software.

	PATENT	COPYRIGHT	TRADE SECRET	TRADEMARK
Term	17 years from date of grant	At least 50 years	Potentially infinite	Potentially infinite
Nature of Protection	Protects inventive concept	Protects form of expression only, *not* substance or content	Prevents competition from learning the trade secret	Protects against others trading on owner's reputation
Scope of Protection	Prevents others from making, using, or selling products embodying the inventive concept	Prevents outright copying and "derivative works" – no protection against independent development	Protects technology so long as maintained secret – no protection against independent development	Prevents use of technology only when a likelihood of confusion exists as to source or origin of product
Applicability to Software Products	Applicable unless inventive concept is a *mathematical* algorithm that is not applied in any manner to physical process steps or apparatus Inventive concept must be "novel" and "nonobvious"	Applicable to "original works of authorship." such as human-readable documentation, listings, and source code programs Controversy as to applicability to object code programs and firmware	Historically applicable to software products Controversy as to applicability to software due to preemption by federal copyright statutes	Applicable to software products
Compatible Concurrent Forms of Protection	Trademark, copyright	Trademark, patent	Trademark	Patent, copyright, trade secret
Compatible Sequential Forms of Protection	Pior to patent grant, trade secret (so long as no statutory bar) After lapse of grant, trademark, copyright	After lapse of copyright, trademark	After loss of secret, copyright, trademark	

The Hazards of Publication

Publishing information about a potentially patentable idea may place the idea in the public domain. As the United States patent law says: "A person shall be entitled to a patent unless . . . the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States . . ."

The law doesn't mean that nothing at all can be published. The concern is with dissemination of information so complete that a person skilled in the art could construct and operate the invention. If such information is published more than a year before the filing of an application, patenting is barred in the United States.

The above is an oversimplification that applies to U.S. practice. Other nations take a less liberal view. They do not provide a one year margin for filing. For example, the laws of most European countries provide that an invention cannot be patented if it forms part of the "state of the art" before the *priority date.*

For Tek purposes, the priority date is usually the date of filing of the U.S. application.

The interpretation of state-of-the-art is very broad, encompassing everything that has been made accessible to the public in any manner – in any country. Thus, while publication of an invention within the year preceding the U.S. filing date is not a bar to the U.S. application, such publication is almost always fatal to corresponding European applications.

In any case, before any conference paper is given or any article is sent to a magazine, the writer (inventor) should ensure appropriate steps have been taken to protect patentability. (See: Guidelines for Consulting the Patent, Trademark and Licensing Department, page 12.)

Invention Record Notebooks

To protect an invention by patenting you must have records to prove the when and what of your work. You must record the date of when the idea was conceived and the date that the idea was reduced to practice. It is equally important to identify all contributors to the invention and to describe relevant facts clearly and completely. To do this, include relevant sketches, diagrams, test data, and photos. Then have two associates (other than co-inventors) who understand the recorded information sign and date the pages, identifying the witnessed pages by number. All this should be done in an *Invention Record Notebook.*

For non-patent records, other media should be used. The notebooks are not intended for recording routine test data of little or no relevance to a new idea, concept, development, discovery, or invention. Notebooks are available from Patents, Trademarks, and Licensing, Y3-121, ext. Y3-8168.

Foreign Patents

A U.S. patent protects only within the jurisdiction of the United States. Foreign patents must be obtained for protection in other countries.

By international treaty, foreign applications filed within the year following the filing of a U.S. application gain the benefit of the U.S. application's filing date. This is important, since in almost all foreign countries the patent goes to the first person to file, not to the first inventor.

Patents as Technical Literature

The privilege of a patent is "bought" with the disclosure of information. These disclosures make the patent offices of the world vast storehouses of information.

The inventor, through the published patent, tells any person "skilled in the art to which the invention pertains" enough so that person could reproduce and use the invention. In addition, applicants generally state the background technology for their inventions and cite the closest prior art.

With all this technical information available, why don't more people use it? To put this question in perspective consider how little of this information is available elsewhere. In the United States, only about 20 percent of the technical information contained in patents is ever published elsewhere. In Great Britain, the figure is only six percent.

Perhaps this resource is unused because engineering schools teach the use of journals as the best way to research the literature. According to one survey conducted by NASA, the deans of engineering schools seldom use patents as technical resources.

Perhaps it's the legalese that discourages the engineer. Yet patents are supposed to be stand-alone documents, understandable by average practioners in a field. But words in law do not necessarily mean what they mean in ordinary usage.

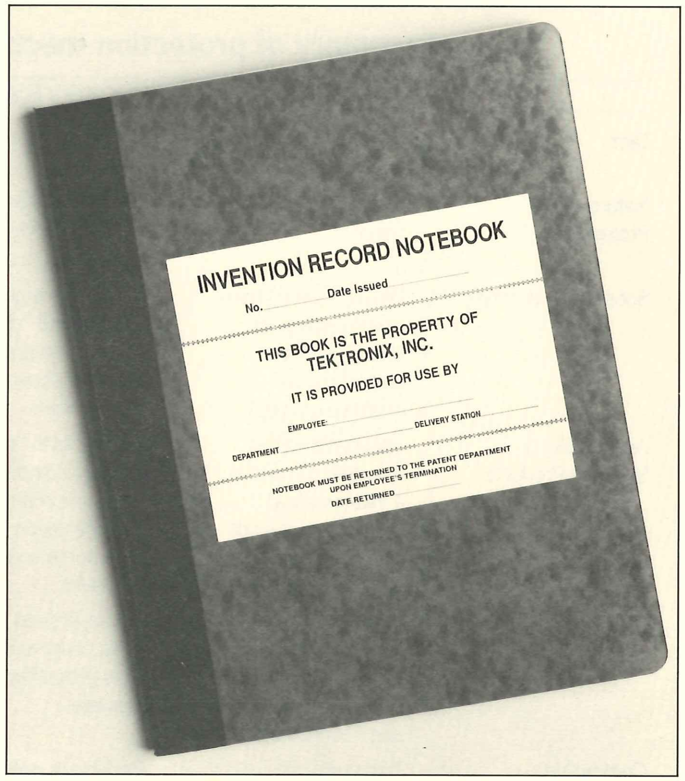

Figure 2. Complete, witnessed records are essential supports for the protection of inventions. The *Invention Record Notebook* is the place for these records.

Because it is beneficial to the owner of a patent to have that patent as broad as possible, patent attorneys word patent claims such that they have a better probability of encompassing later modifications and improvements – including extensions entirely unforeseen by the inventor. And the patent attorney has to guard against making the claim for the achievement seem *obvious* to the examiners and judges who have the "benefit" of hindsight. In such writing, the law requires precise description, in fact it is essential. But it is not necesary to elaborate beyond a full description; it not necessary to be "helpful" beyond the legal minimum "full description."

In addition to other limitations on the literature value of patents, the filing classifications are adapted to patent law. What works in an engineering library doesn't work in searching patent collections for engineering information. You have to learn the system to use it.

Another problem is that only about 30 places have complete patent collections. The one nearest to us is in Seattle at The School of Engineering, University of Washington. These collections are called Patent Depository Libraries and are open to the public.

Continued on page 11

United States Patent [19]

Means

[11] **4,055,776**

[45] **Oct. 25, 1977**

[54] **CCD DIFFERENTIAL CURRENT APPARATUS**

[75] Inventor: **Robert W. Means**, Lausanne, Switzerland

[73] Assignee: **The United States of America as represented by the Secretary of the** Navy, Washington, D.C.

[21] Appl. No.: **735,652**

[22] Filed: **Oct. 26, 1976**

[51] **Int. Cl.**[2] **H03K 5/20**

[52] **U.S. Cl.** .... **307/355;** 307/208; 307/221 D; 307/282

[58] **Field of Search** .... 307/282, 221 D, 221 C, 307/208, 235 F, 355

[56] **References Cited**

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3,819,953	6/1974	Puckette et al.	307/221 D
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381,161	5/1973	U.S.S.R.	307/235 E

Primary Examiner—John S. Heyman
Attorney, Agent, or Firm—Richard S. Sciascia; Ervin F. Johnston; John Stan

[57] **ABSTRACT**

An inductively coupled current apparatus for differential tap currents used in conjunction with charge coupled devices (CCDs) permits the current differences flowing in tapped clock lines of charge coupled devices to be conveniently measured.

3 Claims, 1 Drawing Figure

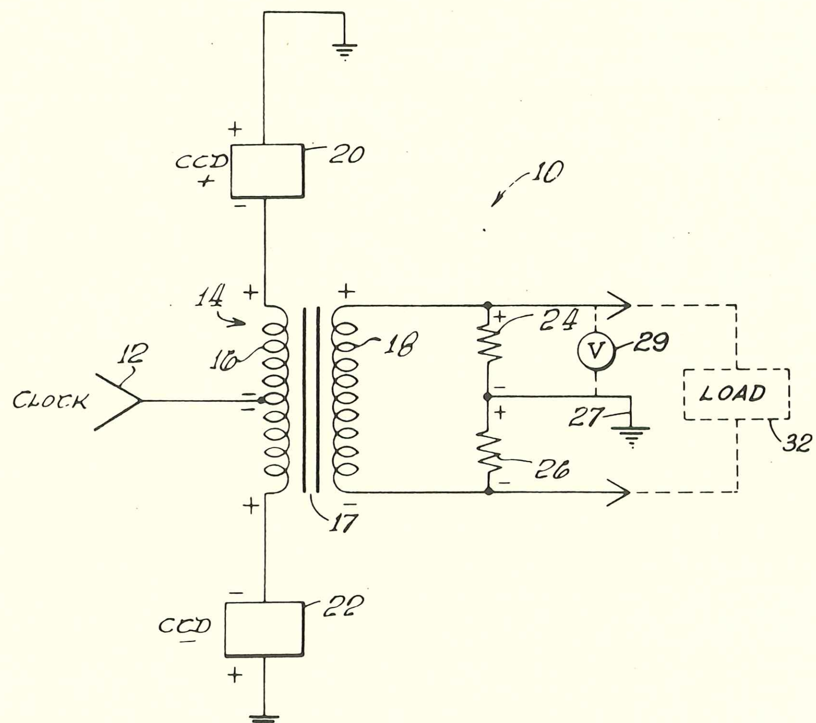


Figure 3. To give readers an idea of content and readability, we have reproduced this sample of patent documentation. The sample is continued on page 10.

CCD DIFFERENTIAL CURRENT APPARATUS

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

FIELD OF THE INVENTION

This invention pertains to the field of solid state physics. In greater particularity, this invention pertains to solid state electronic circuits. By way of further characterization, this invention pertains to the field of charge coupled devices. In still greater particularity, this invention pertains to an arrangement to measure differential currents flowing in tapped clock lines of charge coupled devices.

DESCRIPTION OF THE PRIOR ART

Prior art methods of measurement of differential current pulses flowing in the clock lines of charge coupled devices employed capacity coupled drivers which cooperated with pull-down transistors, integrating capacitors, and sample and hold circuitry. Although initially satisfactory, as the state-of-the-art of charge coupled device circuitry advanced, the prior art arrangements began limiting the dynamic range and useful linearity attainable with charge coupled devices. These limitations were especially apparent at higher frequencies.

SUMMARY OF THE INVENTION

This invention provides an improved arrangement for measuring differential currents flowing in the clock and driver lines of charge coupled devices by employing an inductance circuit which is responsive only to the differential currents flowing in the clock driver lines. It thereby develops a current which is transformer-coupled to a non-inductive resistance load, which may be utilized by conventional voltage amplifying and integrating circuitry.

STATEMENT OF THE OBJECTS OF INVENTION

It is accordingly an object of this invention to provide an improved electronic circuit.

A further object of this invention is to provide a differential current tap for charge coupled devices.

Yet another object of this invention is to provide an inductively coupled differential current tap for charge coupled circuitry.

These and other objects of the invention will become more readily apparent from the ensuing specification when taken together with the drawings.

BRIEF DESCRIPTION OF THE DRAWING

The FIGURE illustrates a schematic representation of the circuitry of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The circuit of the invention is illustrated generally at **10**, for connection to a source of clock signal **12**. Of course, the source of clock signals **12** may be any conventional state-of-the-art clocking circuit used in modern electronic systems.

A center-tapped primary inducing **16** forms the primary winding of the transformer **14**. Each end of center-tapped primary inductor **16** is connected to the clock input lines of suitable charge coupled devices to be clocked by source of clock signals **12**. The charge coupled device clock lines employing positive tap weights are shown as a lumped lead **20** and, similarly, all of the negative tap weights are shown as the lumped lead **22**. Currents flowing in the clocked lines due to the difference of conducting states of leads **20** and **22** will be seen to be flowing in opposite directions within center-tapped primary inductor **16**, as may be seen from the ± polarity signs in the FIGURE, and, therefore, only the differential current is inductively coupled to a secondary winding **18**. The ends of secondary winding **18** may be, in turn, connected to a non-inductive resistance load, shown by resistors **24** and **26**.

As illustrated, the non-inductive resistive load is conveniently comprised of resistors **24** and **26** which are connected to either end of secondary inductor **18** and thence to a ground connection **27**. Thus, it may be seen that resistors **24** and **26** provide a convenient load by which the differential currents flowing in the clock lines may be conveniently measured, for example, by voltmeter **29**. Such resistances may have their IR voltages conveniently coupled, as indicated by arrows to state-of-the-art amplifying and integrating devices **31** for effective utilization thereby.

Transformer **14** may be of any convenient design using good pulse transformer design techniques. Thus, transformer **14** may be a toroid or other conventional transformer configuration and the placement of center tapped primary conductor **16** and secondary conductor **18** to provide optimum inductive coupling may similarly be governed by conventional pulse transformer techniques. In the example shown, a magnetic core **17** provides the necessary inductive coupling. Similarly, by employing conventional design techniques, the number of turns and size of the primary and secondary inductors may be controlled for the specific application and circuitry involved.

The foregoing description taken together with the appended claims constitute a disclosure such as to enable a person skilled in the solid state physics and electronic arts and having the benefit of the teachings contained therein to make and use the invention. Further, the structure herein described meets the objets of invention and generally constitute a meritorious advance in the art unobvious to such a person not having the benefit of these teachings.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings, and, it is therefore understood that within the scope of the disclosed inventive concept, the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A differential current apparatus for use with a source of clock signals, comprising:

at least a pair of differentially coupled plural charge coupled solid state devices;

a center-tapped primary inductor, connected at one end to one of the said pair of charge coupled devices and connected at the other end to the other of said pair of devices, the center tap of said primary inductor connectable to said source of clock signals; and

a secondary inductor inductively coupled to said center-tapped primary inductor for signal transfer therebetween;

whereby when a clocking pulse is applied to the center tap of the primary of the inductor, comprising a differential current is caused by the coupled clock pulses flowing in said center-tapped primary.

2. A differential current apparatus according to claim **1** further comprising:

said source of clock signals connected to said center tap of said primary inductor.

3. A differential current apparatus according to claim **1** wherein said center-tapped primary inductor is inductively coupled to the secondary inductor by means of a core of magnetic material.

* * * * *

Whatever the traditional obstacles built into the system, the system is public and documents a vast assemblage of technology. In computerized searching is the potential for easier access to this resource.

Summary

Protecting Tektronix technology is esential to the continued success of the company.

To prevent others from using our hard-earned technical achievements, use an *Invention Record Notebook.* Avoid premature disclosure by promptly communicating the invention to the Patent department before publishing or presenting your ideas outside Tek. Initiate the patenting process with your organization's patent committee.

For more information, call one of Tek's patent attorneys (see page 12). ☐

Bibliography

IEEE Transactions on Professional Communications, Volume PC-22, No. 2, June 1979

A LANDMARK DECISION: TEK vs THE UNITED STATES

In the '50s, many customers felt there was only one oscilloscope – the Tektronix 530/540 Series. In effect, this forced the U.S. Government to sole-source from Tek, a purchasing constraint at odds with "good procurement practice." What happened? The 1979 Annual Report tells the story:

Tektronix vs. U.S. Ended

A dragged-out, costly and attritive legal contest ended in late December when the U.S. Government paid us $4.5 million for three of its supply contractors having infringed eight Tektronix patents back in our early days.

The case took over 17 years, and had to straddle a Government countersuit that made legal history. It required 10 years to reach a decision in our favor, and eight more for the court to compute what the infringement would be worth.

In the late '50s, the Government, seeking a second supplier for Tektronix-quality oscilloscopes, accepted bids from three other companies whose products, to qualify, had to infringe our patents. (This was not an uncommon Government procurement practice at the time.)

We objected, and asked for compensation; the Government refused. We filed suit March 2, 1961, in the U.S. Court of Claims, asserting that our patents had been infringed. The Government brought in the three contractors as third-party defendants: LaVoie Laboratories, Hickok Electrical Instrument Company, and Jetronic Industries.

The U.S. Counterpunches

The suit didn't get off the ground; the Government, in a tit-for-tat move, pointed out that our scopes contained two of their patents, and in November 1962 countersued us for infringement. The Government had never before contested use of its patents by any private company.

As soon as the counterclaim was announced, we were swamped by advice from inside and outside our industry. Some offered financial help, if needed; some, moral support, should we lose our nerve.

But others warned, don't take on the Government; the odds favor Goliath. (Tek was a little outfit then, with less than $100 million in sales; and the Government seemed about as big as it does now – a formidable opponent, with resources for a long, tough legal fight.)

On the face of it, the Government had a good point: Our products did use its patents (as did the products of many U.S. companies.) But we argued that, throughout the century-old history of the U.S. Patent Office, the government had not merely allowed but actively encouraged free use of patents assigned to it.

A quarter of a century ago Tek's right to exclusively build the 535 and 545 oscilloscopes was challenged. Without eight patents, Tek history would be different.

The court went along with us, and on October 15, 1965, denied the countersuit.

The main trial began in February 1965 and, after adjournments for this reason and that, ended on March 4, 1966.

Tek Wins

It was four years later that the trial commissioner issued his opinion. A year after that the Court adopted it (June 11, 1971) and gave its opinion: That our patents were valid and had been infringed. We'd won.

But then came the accounting trial, to see what "reasonable and entire compensation" meant in dollars. It began December 10, 1973; then came the commissioner's opinion, the Court's memorandum of opinion; oral arguments . . . Judgement was finally entered April 19, 1978 for $4,238,307 plus $491.66 per day interest from July 1, 1977 until paid.

That was the end of it – almost. The Government made noises about seeking Supreme Court review, but must have thought better of it. (In a dying twitch, Hickok, one of the third-party defendants, did take that step, but the Supreme Court refused to consider the case.)

The payment, received December 29, 1978, was for $4,506,753.36. Although not the precise number we had in mind, we feel it did compensate us to some degree.

Here's the real importance of the case:

The U.S. Government has now changed some of its procurement practices, and is less free in its use of privately held patents. That's the real benefit, and the whole of U.S. industry shares it. □

GUIDELINES FOR CONSULTING THE PATENTS, TRADEMARKS AND LICENSING DEPARTMENT

Among Tektronix' most important assets are its "intellectual property." Intellectual property is a broad classification, including inventions, scientific discoveries, industrial designs and processes, manufacturing know-how, and other technology. Literary works too are intellectual property; software, technical literature, and sales literature are, in the eyes of the law, literary works. And then there are trademarks – commercial names and phrases, product designations, and so forth. These too are property produced by the intellect.

Intellectual property, whether embodied in hardware, software, or written in any medium, includes:

- The results (for example, designs, manufacturing know-how, etc.) of research and development work performed by Tektronix.
- The results of research and development work by others but funded by Tektronix.
- The results of research and development work jointly performed and/or jointly funded by Tektronix and another party.
- Know-how and technical design data purchased by Tektronix.

The Tektronix Patent, Trademark & Licensing Department, in the Office of The General Counsel, has been charged with legally protecting the company's intellectual property. A member of the department must be consulted whenever there is a question of ownership, transfer, protection, assertion, or defense of rights in such property. Specific instances requiring consultation include:

- The *acquisition or transfer* of intellectual property rights by assignment, agreement, license, or otherwise. Patents, Trademarks & Licensing should be consulted early, preferably before negotiations start.
- The *protection* of intellectual property rights. Some agreements can restrict our ability to disclose information, limit our use of information or property, or mutually or unilaterally obligate us to protect the property rights of the other party.
- The *Infringement* of Tektronix' rights or the rights of others in intellectual property. □

THE PATENT ATTORNEY

What differentiates the patent attorney from fellow members of the bar? Unquestionably, the difference is technical background.

A patent attorney is formally qualified by three things:

(1) Graduation from a law school

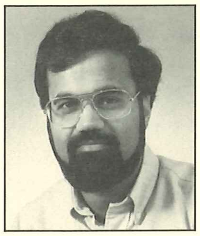
(2) Admittance to a state bar

(3) Admittance to the Patent Bar by passing an examination by the United States Patent and Trademark Office

To take the exam, let alone pass it, the prospective patent attorney must have a technical degree or significant technical experience. Patent work requires a solid understanding of the appropriate underlying technology as well as a firm grasp of the law.

Bob Hulse is Tek's general patent counsel. Other Tek patent attorneys working with Bob are John Smith-Hill, Tom Noe, and John Winkelman. Don't hesitate to call them.

CONSISTENT, ACCURATE HYBRID RESISTORS ACHIEVED WITH AN EMPIRICAL MODEL



Raj Garg is a process engineer in Hybrid Circuits Development (formerly HCE). Raj joined Tek in 1979 and spent two years in Hybrids Manufacturing before assuming his current position. He has a bachelor's degree in metallurgical engineering and a master's in ceramic engineering.

With the decentralization of hybrid design at Tek, it has become increasingly important to make our design tools more accurate. Where in a centralized function information on various processing effects could be passed from person to person, this information must be included in hybrid design software, such as HCAD. This article reports on an effort to improve the accuracy of HCAD designed thick-film resistors.

It is widely understood that the ideal resistance equation based on Ohm's Law, $R = \varrho \cdot L/W$ (where ϱ is the film sheet resistivity, and L and W are the length and width of the resistor) does not provide accurate thick-film resistor designs. The equation neglects the effect of several material and processing factors on the resistance value. Three main phenomena cause deviations from the ideal behavior:

1. The *termination effect* – the diffusion of the conductor material into the resistor
2. *Inter-diffusion* between the substrate and resistor materials
3. *Inherent variations in screen-printing* techniques used in thick-film processing

Because the degree of deviation from ideal resistance depends strongly on the diffusion distances relative to the length of the resistor, diffusion affects small resistors more than large ones. Although most materials have a negative termination effect (reducing the effective sheet resistance), positive termination effects have been observed for low-value resistor pastes, presumably due to 'modifiers' in these materials.[1]

The variations inherent in screen-printing techniques also contribute to the non-ideal behavior of the resistor. Small geometry resistors tend to print thicker than larger ones, making the film thickness, and therefore the sheet resistance, a function of the resistor geometry.

The purpose of this study was to create resistor design equations that include the processing effects, and to incorporate these equations into Tek's hybrid design software, HCAD.

Literature Review

Several authors have suggested theoretical and empirical models for designing thick-film resistors. The empirical models are gaining wider acceptance because of their accuracy over a range of resistor geometries. Empirical modelling usually requires an initial equation and a set of independent and dependent variables. This data is used in regression analysis for estimating the unknown parameters in the equation. Depending upon the complexity of the initial equation, regression can use the simple linear, multiple linear, polynomial, or nonlinear techniques.

Most significant among these empirical approaches is that by Zarnow,[2] who proposed the following model:

$$R = \varrho \cdot \frac{L^{e_1}}{W^{e_2}} \qquad (1)$$

where e_1 and e_2 are exponents added as 'adjustors.' The effects of material and process variables are intrinsically 'lumped' together in the exponents. To simplify the regression analysis, equation (1) was linearized by taking the logarithm of both sides, as follows:

$$\text{Log } R = \text{Log } \varrho + e_1 \text{ Log } L - e_2 \text{ Log } W \qquad (2)$$

A least-squares fit was then generated between independent variables Log L and Log W and dependent variable Log R, using multiple linear regression techniques. Zarnow estimated parameters ϱ, e_1, and e_2 for each resistor/conductor paste combination.

Golonka[3] has proposed another empirical approach based on Naguib's[4] theoretical model, assuming exponential dependence of film thickness on resistor length and width:

$$R_{\square} = \varrho\,(ae^{-L} + be^{-W} + 1)^{-1} + \frac{c}{L} \qquad (3)$$

where $R_{\square}$ is the sheet resistance and ϱ, a, b, and c are parameters.

Experimental Investigation

Our initial experimental work was performed on Zarnow's model using parts printed with ESL5835 Pt-Au conductor and DuPont 1441 (10 KΩ/□) resistor pastes. We chose this combination because it yields repeatable results. Note that under ideal conditions, the parameters ϱ, e_1, and e_2 in equation (1) would therefore be 10,000, 1, and 1, respectively.

All resistance measurements were made on a GPIB system consisting of an HP 3495A Scanner, a Fluke 8502A Programmable DMM, and a Tek 4054 Desk-Top Graphics Computer/Controller with Tek 4907 File Manager. Measured values were compared with those predicted and the distribution of the ratio "R actual/R predicted" was used to evaluate the models, with the best case having a mean = 1 and a standard deviation $s = 0$.

To establish a data set for regression analysis, we designed a resistor test pattern with a broad range of lengths and widths – H1150A (figure 1). This pattern has 59 resistors on a 1.0″ × 2.0″ substrate, with widths varying from 0.020″ to 0.070″ and lengths from 0.020″ to 0.310″.

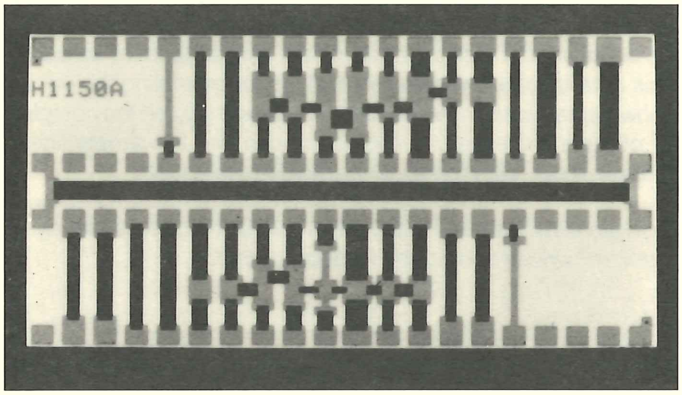


Figure 1. Test pattern, H1150A.

Because film thickness varies with resistor geometry, a standard-geometry resistor is an essential reference for accurately adjusting the screen printer. This standard geometry is called *test key* in this article. The test-key can be included on a sacrificial border of an array pattern, and on individual circuits if real estate permits.

The test-key must have low dispersion of resistance – that is, it must be repeatable. We evaluated this dispersion by measuring the coefficient of variation (standard deviation/mean) for different lengths and widths. Figure 2 shows a plot of dispersion versus length for three conductor types for a width of 0.050″. Even though we found dispersion to be inversely related to resistor size – the smaller the length and/or width, the greater the dispersion – we chose to use a resistor of 0.050″ × 0.100″ for the test-key. As we expected, the dispersion for Pd-Ag conductors was higher than gold, which in turn was higher than Pt-Au.

Model A

To estimate the parameters in equation (2), we used a Tektronix software package (PLOT 50 STATISTICS – MULTIPLE LINEAR REGRESSION) and the Tek 4054 system as follows:

$$R = 7845.13 \times \frac{L^{1.0741}}{W^{1.0171}}, \quad N = 1650 \qquad (4)$$

The model was experimentally verified on two hybrids, H229D and H897A; both hybrids were (made) using identical conductor/resistor materials. Figure 3 shows the results of two separate tests on H229D, one with no controls and the other with the test-key thickness controlled to a standard value. The 'Λ' and '|' marks under the normal distribution curves represent the mean and 1, 2, and $3s$ points.

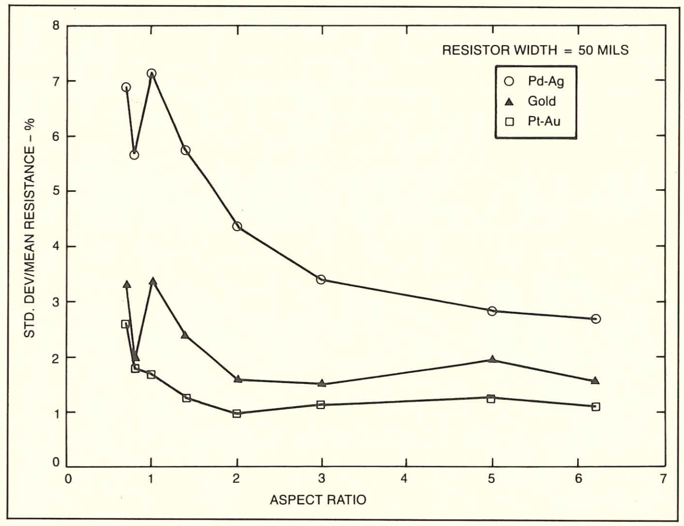


Figure 2. Test-key dimensions.

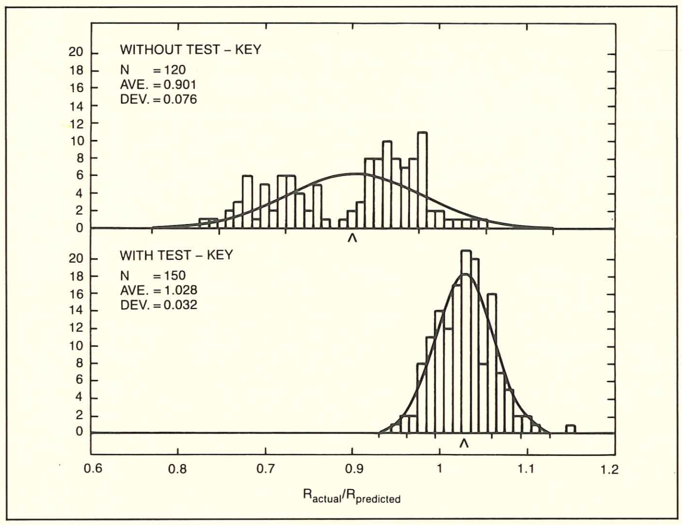


Figure 3. Model A verification.

As can be seen in figure 3, the parts with the test-key show a much better distribution: $s = 0.032$, as compared to 0.076 for the parts without the test-key, and a mean closer to 1. The distribution of "R actual/R predicted" for H897A, which is the top curve in figure 5, shows a s of 0.063. This value implies that, in actual production, the "as-fired" resistors will be in a window of ±18.9% (3 × 6.3%), based on the $3s$ spread of a normal population, and suggests some need for improvement.

Proposed Tek Model

A new model, with two additional parameters, defines a thick-film resistor more accurately.

$$R = \varrho \cdot \frac{(L - A)^{e_1}}{(W - B)^{e_2}} \qquad (5)$$

While the three variables (independent: L and W, dependent: R) are the same as in other models, the new model has five parameters: ϱ, A, B, e_1 and e_2. The new parameter A represents the extent of conductor diffusion in the resistor and B describes the width differences between designed and screen printed resistors.

Equation (5) is nonlinear, as is equation (1). Although the model in equation (1) can be transformed (by taking logarithms) to have a linear relationship between the variables, equation (5) can't be made linear because A and B are unknown. It will remain nonlinear, whatever the transformation applied. Such models are intrinsically nonlinear.[5]

To evaluate equation (5), two nonlinear regression packages were tried: PLOT 50 STATISTICS – NON-LINEAR ESTIMATION for the Tek 4054 system, and SPSS[6] (Statistical Package for the Social Sciences) for Cyber 175. Due to problem complexity, we used SPSS for the regression analysis.

Model B

Using the identical data used for Model A, equation (5), and SPSS, the Model B was generated:

$$R = 56149.9 \times \frac{(L - 5.66)^{1.0141}}{(W + 12.51)^{1.351}}, \quad N = 1650 \qquad (6)$$

where L and W are in mils and R in ohms.

The results of nonlinear estimation surprised us, because the parameters ϱ, A, B, e_1, and e_2 deviated significantly from their ideal values of 10,000, 0, 0, 1, and 1, respectively. Further analysis of the statistical methods explained the discrepancy. Most regression programs, including the ones we used, minimize the sum-of-squares function for parameter estimation. For Model B, the dependent variable is R; therefore, this function is:

$$\text{Sum of Squares (SS)} = \sum (R_{actual} - R_{predicted})^2 \qquad (7)$$

In Model A, the dependent variable is 'Log R' (equation 2), and hence the sum of squares function is:

$$SS = \sum (\text{Log } R_{actual} - \text{Log } R_{predicted})^2 \qquad (8)$$

or

$$SS = \sum \left(\text{Log } \frac{R_{actual}}{R_{predicted}}\right)^2 \qquad (9)$$

In the limiting case when the error function becomes zero, equations (7) and (9) give identical results. In all other cases, equation (7) gives more weight to large-value resistors because the error 'R actual – R predicted' is larger for large-value resistors. For example, consider two resistors R1 and R2:

	Actual	Predicted	Difference	Error
R1	10 KΩ	8 KΩ	2 KΩ	20%
R2	1 KΩ	800 Ω	200 Ω	20%

While the percent errors (inaccuracy) in both cases are identical, the resistance difference is much higher in the case of R1. Equation (7) minimizes the total absolute difference, while equation (9) minimizes the total percent error. Thus, equation (9) using Log R as the dependent variable gives an unbiased fit.

Figure 4 illustrates this point further by comparing equation (1) (nonlinear estimation using R as the dependent variable) with equation (2) (multiple linear regression using Log R as the dependent variable).

Model C

To apply the 'Log R' approach to the Tektronix model, we took logarithms of both sides of equation (5), as follows:

$$\text{Log } R = \text{Log } \varrho + e_1 \text{ Log } (L - A) - e_2 \text{ Log } (W - B) \qquad (10)$$

Model C was then generated using the data used for Model A:

$$R = 8765.8 \times \frac{(L - 4.15)^{1.027}}{(W - 2.06)^{0.986}} \qquad (11)$$

where L and W are in mils and R in ohms.

The performance of Model C was compared to Model A and to the ideal resistance equation for the H229D and H897A hybrids. In both cases, the Model C was superior to Model A. Figure 5 – generated with one set of 'R actual' values, with different 'R predicted' values for different models – shows the results for the H897A.

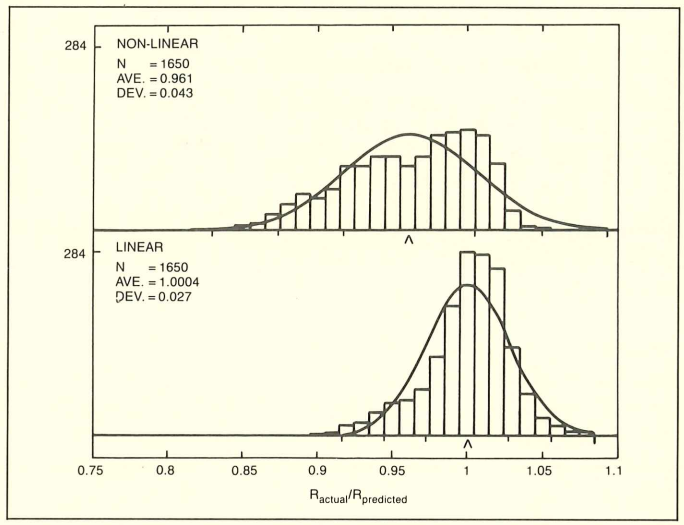


Figure 4. Equation (1) fit evaluation.

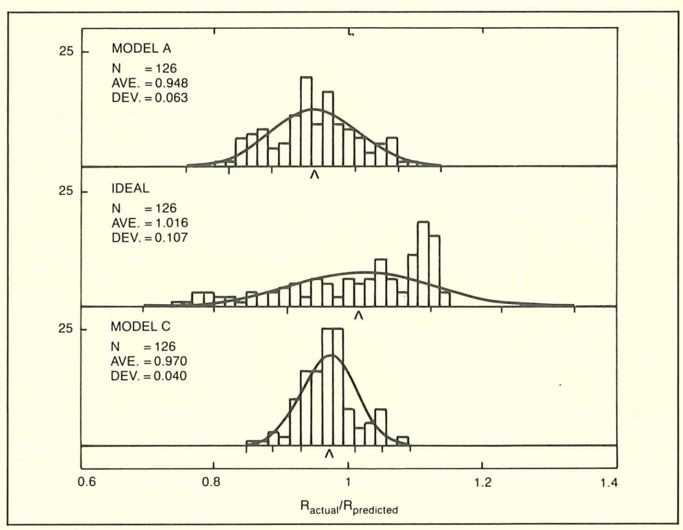


Figure 5. Model verification on H897A.

TABLE I
Equation (5) parameters for DuPont's BIROX 1400-Series.

• Gold (Electro Oxide 7185)

	ϱ	A	e_1	B	e_2
DP 1411 (10 Ω)	11.92	−5.65	1.0306	0.66	1.0626
DP 1421 (100 Ω)	151.89	−3.08	1.0172	−0.17	1.0694
DP 1431 (1 KΩ)	1.12K	−0.39	1.0187	1.58	1.0100
DP 1441 (10 KΩ)	18.16K	1.08	1.0143	−0.25	1.0649
DP 1451 (100 KΩ)	322.51K	1.89	1.0161	−3.96	1.1883
DP 1461 (1 MΩ)	1.72M	1.29	1.0162	−1.80	1.1872

• Pd-Ag (DuPont 4093)

	ϱ	A	e_1	B	e_2
DP 1411 (10 Ω)	16.21	−10.21	1.0297	−1.72	1.1274
DP 1421 (100 Ω)	191.22	−1.96	1.0033	−2.09	1.1085
DP 1431 (1 KΩ)	1.04K	4.43	1.0430	0.44	1.0249
DP 1441 (10 KΩ)	20.20K	8.73	1.0367	−2.75	1.1170
DP 1451 (100 KΩ)	186.22K	12.00	1.0714	−2.86	1.1373
DP 1461 (1 MΩ)	1.83M	11.49	1.0488	−4.41	1.2374

Final Models

A quick evaluation of the Golonka model (equation 3) using nonlinear regression techniques indicated that its accuracy was much less than the earlier models and the sum of squares much higher. Therefore, Model C, based on equation (10), was selected for generating the parameters for the commonly used materials at Tektronix. Table 1 contains these parameters for DuPont's Birox 1400 resistor system with two types of conductors: DuPont 4093 Pd-Ag and Electro Oxide 7185 gold.

Several observations are important:

- Parameter ϱ tracks the sheet resistance of all six decades, 10 Ω to 1 MΩ, quite well.
- Parameter A follows the conductor diffusion in the resistor. Its value starts off negative for low value pastes, indicating the positive termination effect and the increase in effective sheet resistance reported by others.[1] The value of A continues to increase and ends up highly positive for 100 KΩ and 1 MΩ paste, indicating the negative termination effect and the decrease in effective sheet resistance that have been commonly observed.
- The absolute values of A are higher for Pd-Ag than for gold, implying more conductor diffusion for Pd-Ag. This observation is also common.

It is worth noting that the parameters in table 1 account for the specific process and material effects encountered at Tektronix. Even if another manufacturer used identical materials, the subtle differences between processes could change the values of these parameters.

Other Applications: Capacitors, Inductors, Resistors

Our empirical approach can also model other elements of a thick-film hybrid, benefiting the designs of other resistors (top-hat, serpentine, etc.), capacitors, and inductors.

Extrapolation – that is, using the models to estimate the value of the dependent variable outside the limits of the original data – should be avoided: extrapolation is a pitfall of regression analysis and empirical modelling. However, the chances of serious errors can be minimized by using an empirical model that has some theoretical basis.

We also studied the feasibility of an empirical model for thick-film parallel-plate capacitors. DuPont's 9429 dielectric and ESL's 5835 Pt-Au conductor was used for both top and bottom electrodes. A simple extension of the ideal capacitance equation resulted in:

$$C = 0.0051 \times L^{0.8509} W^{0.9446} \qquad (12)$$

where C is the capacitance in pF, and L and W are the length and width in mils.

The first term on the right side of the equation combines the effect of the dielectric constant (9–12), permittivity of free space, and dielectric thickness (1.4 mils). The L and W replace the area term in the ideal equation, while the exponents incorporate the variation of fringing fields with length and width. The larger of the two sides of the capacitor was defined as the length.

Although some verification of the capacitor empirical model was done, such efforts won't be meaningful until the paste manufacturers tighten the tolerances for the dielectric constants of their products.

Conclusion

We conclude that the following new empirical model provides for consistent and accurate thick-film resistor designs:

$$R = \varrho \cdot \frac{(L-A)^{e_1}}{(W-B)^{e_2}} \tag{5}$$

Parameters ϱ, A, B, e_1, and e_2 need to be estimated empirically for each conductor/resistor material combination. The distribution of the ratio "R actual/R predicted" for this model has a mean close to unity and a smaller standard deviation than other models. This distribution indicates that actual resistor values are more accurately predicted when this model is used. For the nonlinear estimation of the parameters in equation (5), Log R instead of R should be used as the dependent variable to achieve an unbiased least-squares fit.

For More Information

For more information, call Raj Garg, 627-6387.

Acknowledgments

Many colleagues have contributed to this work. In particular, I am grateful to Caryl Verrinder for preparing the samples, and to Wayne Huebner, summer intern from University of Missouri – Rolla, for his efforts on capacitor modelling. □

A paper, "Empirical Approach to Resistor Design," has been published in *The Annual Proceedings of ISHM 1983.*

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EMI-SHIELDING PAINTS EVALUATED

Are you considering a Ni- or Cu-loaded paint for EMI shielding? Jerry Holly, Metals Research and Development, has evaluated 24 such coatings and would like to share a report on the evaluation.

These coatings were evaluated:

NS 83-331, Enamel FBBS-2681, Mass & Waldstein

E-Kote #3063LX, Acme

E-Kote #3063

Isolex R-65, Bee Chem. Co.

SL20563 B#5401, Red Spot

Electrodag 439, Acheson Colloids Co.

Electrodag 440 #1, Acheson Colloids Co.

Electrodag 440 #2, Acheson Colloids Co.

Evershield EC-N-501, E/M Lubricants

X Coat 210-1, ElectroKinetic Systems Inc.

X Coat 220, ElectroKinetic Systems Inc.

X Coat 210X, ElectroKinetic Systems Inc.

Cobaloy P212 Type 1B, Cobaloy, Div. of Graham Magnetics

Cobaloy P212 Type 1A, Cobaloy, Div. of Graham Magnetics

Corbaloy D3300, Cobaloy, Div. of Graham Magnetics

ECCOCOAT CP1218-39, Emerson & Cuming

Sermetel, Sermetel Inc., Mtls. Division

599 SA-A8219-1, Spraylat Corp.

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49 B-3, Advanced Coatings & Chemicals

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NOVEMBER

TITLE	AUTHOR	PUBLISHED	PRESENTED
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Empirical Approach to Resistor Design	Raj Garg		ISHM Conference, Philadelphia, PA
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A Process for Two-Layer Gold IC Metallization	Doug Summers	**Solid-State Technology**	
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Graphic Workstation Requirements for Computer-Aided Design for Electrical Engineering	Robert Shew		Nikograph Conference, Tokyo, Japan
High Speed, Latchup-Free, 0.5 μm-Channel CMOS Technology Using Self-Aligned TiSi2 and Deep-Trench Isolation	Tad Yamaguchi		International Electron Devices Meeting (IEDM), Washington, D.C.
EMI Shielding with Electroless Copper	Larry Helton and David Jordahl		Society of Mechanical Engineers Chapter Meeting, Portland, OR
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Computer arithmetic; *IEEE Transactions on Computers,* Vol. C-32, No. 4, April 1983, $12.00. JH62075 – Devoted to research in computer arithmetic, features articles and correspondence on code conversion, error analysis, number system comparison, finite precision arithmetic, error-checker implementation.

Solid-State Circuits Conference, 8th European (ESSCIRC '82), Sept. 22-24, 1982 sponsored by IEEE SSC, National Engineering Societies of Belgium and the Netherlands, EUREL, and URSI. Selected papers published in *IEEE Journal of Solid-State Circuits,* Vol. SC-18, No. 3, June 1983, $12.00. JH63834 (not distributed under OOP) – Topics include CMOS technology, digital signal processing, speech processing, GaAs technology.

Computer Arithmetic, 6th Symposium June 20-22, 1983; Sponsored by IEEE C. *Proceedings,* LC 83-80545 (preassigned), ISBN 0-8186-4476-1 (paper), ISBN 0-8186-6476-2 (microfiche), ISBN0-8186-8476-3 (casebound), $30.00. 83CH1892-0 (OOP IE) – Development and applications of computer arithmetic on VLSI, number systems and residue arithmetic, multiplication, numerical error control, algorithms and implementation, case studies, on line and pipeline arithmetic, special topics, and rational arithmetic.

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