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# Engineering News

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# ULTRA-THIN copper clad pc boards

With ultra-thin copper-clad printed circuit boards...

- circuit density can be higher.
- and manufacturing costs lower

...without special efforts or considerations from circuit and layout designers. And ultra-thin clad laminates are available now in a variety of laminate thicknesses.

**Standard** clad is "one ounce" copper (one ounce is the weight of the copper-clad over one square foot of laminate). **Ultra-thin** is variously defined as half-ounce, quarter-ounce, and eighth-ounce clad, but properly it refers to eighth-ounce clad. "Ultra-thin" refers to the thickness of the clad, not to the thickness of the runs that are patterned on the finished board.

Ultra-thin copper-clad laminate can be used anywhere standard clad laminate is used. One exception might be the inner layers of multilayer boards. Half-ounce inner layers are now being used, but quarter and eighth-ounce inner layers haven't yet been evaluated.

## GREATER CIRCUIT DENSITY

Because there is very little undercut of etched runs with ultra-thin (the etching time is shorter), there is much less danger of over etching. So, runs can be placed closer together with ultra-thin clad. Another reason for greater circuit density is that the runs themselves can be thinner.

For example, etching a 5-mil wide run on a one-ounce clad board produces 1.5 mil undercutting on each side of the run. That means there will be only 2 mils of copper in contact with the laminate. The chance of the five-mil run separating from the laminate is great when the base of the run is that small. A three-mil run wouldn't adhere to the laminate at all if one-ounce clad is used.

## MANUFACTURING COSTS ARE LOWER

Manufacturing costs are lower for ultra-thin clad laminates. Less etchant is used, drill life is longer, burr removal is unnecessary, the reject rate is usually lower, and all-copper through-hole plated circuit boards are possible thus eliminating several plating steps.

## THE EPA AND LESS ETCHANT

Electrochem will use about 75% less etchant for ultra-thins than for standard clad boards. The EPA allows Tektronix to discharge one part copper per million parts water into the disposal system. Any reduction in copper etching will help maintain that allowance.

## MORE HITS PER DRILL

Based on our experience at Tektronix, using ultra-thin clad laminate extends the life of pc board drills. One-ounce copper allows about 2000 hits before the drill has to be resharpened, but ultra-thin clad allows up to 6000 hits before resharpening is required.

## ULTRA-THIN technology...where it's at

### THE PAST

Quarter-ounce and half-ounce copper-clad laminates were used in a small way in the early 1960's. At that time, manufacturing problems made them unattractive to produce as well as to use. For example, there was an epoxy bleed-through problem (the epoxy in the laminate bled through pin holes in the copper clad). Those problems have been solved.

Quarter-ounce and half-ounce boards have been widely used since the early 1970's. Eighth-ounce boards have been used by some manufacturers for the last three years.

### AT TEKTRONIX

Tektronix has some half-ounce clad laminate boards in production for multilayer and microwave applications. We are behind the rest of the industry in the use of eighth-ounce boards, but ahead of the industry in environmental (EPA) compliance. A move to ultra-thin clad laminates will help us keep that lead...besides saving us money.

### RECIPE

Here's a basic recipe for making a standard copper-clad laminate into a printed circuit board:

- buy the copper-clad laminate.
- drill holes (to allow conductors to pass from one side of the board to the other) and sand off the burrs formed by the drilling.
- immerse the board in **electroless copper** to make the holes conductive.
- add the **strike plate**, and clean the board.
- print the **image** of the circuit onto the board.
- **pattern plate** copper over all areas not covered by the **resist**, so that you now have plating in all the holes and on all the conductors (runs).
- plate on the **protective resist** (nickel-tin, for example).
- strip away the photo resist (only bare copper is left as background, except where the runs are plated with other metals).
- etch away the background copper.
- clean it up and add solder resist (so that solder won't stick anywhere except where it is needed).
- route to finish fabrication and inspection.

### KEY WORDS

**RUN** - an electrical connection on a printed circuit board.

**ELECTROLESS COPPER** - copper added by immersing the board in a solution, but without electroplating.

**STRIKE PLATE** - thin electroplated copper that helps hold electroless copper.

**PATTERN PLATING** - electroplating copper to required thickness but only on the circuit pattern.

**RESIST** - a material laid down on the board, in places, to prevent some other material from sticking to those places. Solder resist is an example.

**THROUGH-HOLES** - holes drilled in the blank clad board that will be coated with copper, thus providing an electrical connection between the top and the bottom of the board.

**1/8 - 1/4 - 1/2 - 1 ounce clad** - the weights refer to the weight of one square foot of copper as it is clad on the board.

## LOWER REJECT RATE

The reject rate is usually lower for ultra-thin boards than for their one-ounce equivalents. In some cases the difference may seem small (one or two percent). But when you are making 35,000 boards a week, as Electrochem manufacturing is doing, that adds up to a lot of money. The reject rate for a medium density one-ounce board is about 7% to 10%, and for a high density board the rate is about 20%. So the number of boards rejected is significant. Any reduction is important. The most important factor in the increased yield is elimination of undercut which greatly reduces problems caused by borderline filmwork, close tolerance runs and spacing.

## WHAT THE DESIGNER SEES...

From the ECB designer's viewpoint, ultra-thins are the same as standard clad laminates. But, with standard laminate, the designer has to compensate for the part of the run that is etched away. The situation is different with ultra-thin clad. The clad is so thin that etching time is very short...too short for the etchant to eat away much from the sides of the run. What the designer sees on the filmwork is what the designer gets for the finished board.

## BETTER THROUGH-HOLE INTEGRITY

Drilling ultra-thin clad produces fewer irregularities around the drill hole. So, through-hole plating is cleaner.

## HIGH-CURRENT REQUIREMENTS

Most Tektronix designs don't require high-current runs. But, where they are needed, the appropriate areas can be plated to meet the requirements and still keep the advantages that ultra-thin brings to manufacturing pc boards.

## AVAILABILITY

Ultra-thin copper clad laminate is available in all standard laminate thicknesses. There is no supply problem.

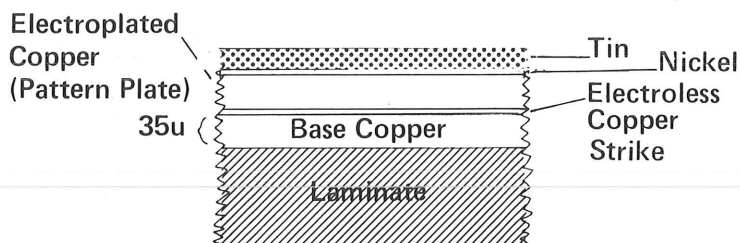
## UL RATING

The manufacturers of ultra-thin clad laminate have Underwriters Laboratories approval. After we make board samples, using our processes, we submit them to UL for testing and for flame ratings. We have begun producing samples for submittal. We have already received UL rating for half-ounce clad material.

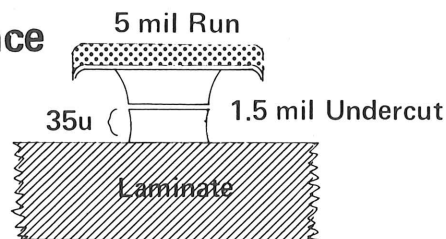
## COST SUMMARY

The manufacturing cost of an ultra-thin clad board is less than the cost of making the same board with one-ounce clad. Drill life is longer, less etchant is used, no sanding is needed, and the reject rate is typically lower.

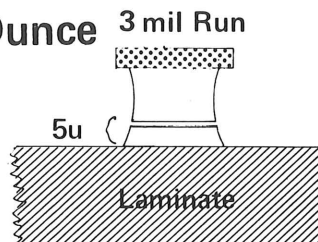
An example makes the savings stand out. Recently the electrochemical engineering support group analyzed the costs of materials and processing for 13 pc boards in a new instrument. They forecasted an annual usage of 35,000 flats a year. The price Tektronix pays for the ultra-thin clad laminate would be \$10,000 more than for the standard clad laminate. However, the processing costs (sanding, etching, drilling) would be about \$48,000 lower for the ultra-thin than for the standard clad. That is a 15% saving of the overall costs of materials and processing.



## One - Ounce Clad



## Eighth - Ounce Clad



Using ultra-thin boards eliminates the overhang on runs. So circuit density can be higher.

## CONFIRMATION

The experience of other companies confirms Tektronix' limited experience with ultra-thin copper clad laminates. Copies are available (from Glenn Schwalbe, extension 5182) of several articles that discuss in detail the nature and advantages of ultra-thin copper clad. The articles are

- "Economic Advantages of Thin Copper Laminates" by Jerome S. Sallo.
- "Thin Copper Foils and the EPA" by Gary Wolfe.

## NEED MORE INFORMATION?

If you would like to know more about ultra-thin clad, give Glenn Schwalbe a call on extension 5182, or drop by 38-350. Glenn works in the electrochem engineering support group (part of Test and Measurements operations).

### The Electrochemical Engineering Group

The electrochemical engineering group has researched the use of ultra-thin copper-clad pc boards for several years. They provided the information for this article.

The purpose of the group is to evaluate new technologies and make them known to the Tektronix engineering community. They propose improvements to old processes and develop new processes as well.

# THE PHASE SYSTEM

Of the products that Tektronix sells, 10 to 15% have been introduced in the last year. Each has been through the new product introduction (NPI) process which is often long and involved. The following overview of the process—the phase system—is a digest of the first chapter of the NPI Guidebook published in February, 1977.

The NPI process has five phases, each defined by a set of activities. A **milestone** marks the end of a phase. To complete each phase many groups in the company must be coordinated. This is done by the project manager for the product to make sure that information flows as it should.

## CONCEPT PHASE

The concept phase is the time between the first idea for a new product and the formal approval of the product proposal. To provide data for the product proposal, the idea should have been thoroughly researched through

- definition of product design and performance goals,
- market analysis,
- financial analysis,
- engineering feasibility studies,
- manufacturing estimates.

If, after all the studies, the new product's sponsors still have confidence in the concept and feasibility, they submit a product proposal to the group vice president for that product area.

Formal product approval (PA) should come as long before completion of the design phase as possible to allow plenty of time for **product development forecasting** (planning the product's route through the rest of the phase system).

## DESIGN PHASE

The design phase begins as soon as the product proposal is approved. The new product introduction plan defines what must be done and known before the design phase is complete. The design completion (DC) criteria are used by engineering, manufacturing, and marketing as a check list to determine when the new product is ready for the evaluation phase.

Formal design completion is announced at a release meeting attended by the product development team with representatives from all design, marketing, manufacturing, and support areas. Each release meeting is chaired by a member of the operation staff of either the Test and Measurement or the Information Display group. The team reviews product development with the DC criteria.

## EVALUATION PHASE

To fully evaluate the new product, the appropriate business unit builds 5 to 10 identical models. The development team evaluates the models to see if they meet design and performance specifications. If there are either design or performance problems, the product will be changed to meet specification. When the prototype release criteria (defined by the NPI plan and the appropriate evaluation phase activities are met, the evaluation phase is at an end.

The evaluation phase is usually called "A" phase.

## VERIFICATION PHASE

Final verification of the new product begins with release of the prototype and ends when engineering releases the product to production. The product development team has several more prototype models built to verify the product in the form in which it will be sold. The whole engineering package (drawings, specifications, parts lists, and schematics) and all other introduction activities are finalized in this phase. Assembly manufacturing becomes much more involved in this phase.

The verification phase is usually called "B" phase.

## PRODUCTION PHASE

After engineering releases the new product, the warehouse receives the parts. Manufacturing builds, calibrates and tests the product. Product support logistics are defined, and customer shipments begin.

## NEW PRODUCT INTRODUCTION MEETINGS

The new product introduction plan is the framework for coordination of the many people involved in a new product. These people must meet regularly for good communication and scheduling.

New product **steering meetings** give the participants a chance to coordinate the development schedule, and report the status of their part of the project. The meeting chairman publishes the minutes of the meetings so that the rest of the corporation knows the progress of the product.

A **release meeting** marks the end of each phase. The meetings are attended by representatives from such groups as:

- division business unit management,
- engineering,
- manufacturing,
- marketing,
- support areas (like component design and environmental test),
- safety,
- customer and service support.

The project manager calls together product development **team coordination meetings** as they become necessary.

A corporate committee, made up of corporate management representatives from operations, marketing and central manufacturing, holds an **NPI review meeting** for each product after its prototype release. The committee reviews the NPI plan with the management of the division that is developing the new product.

## THE NPI GUIDEBOOK

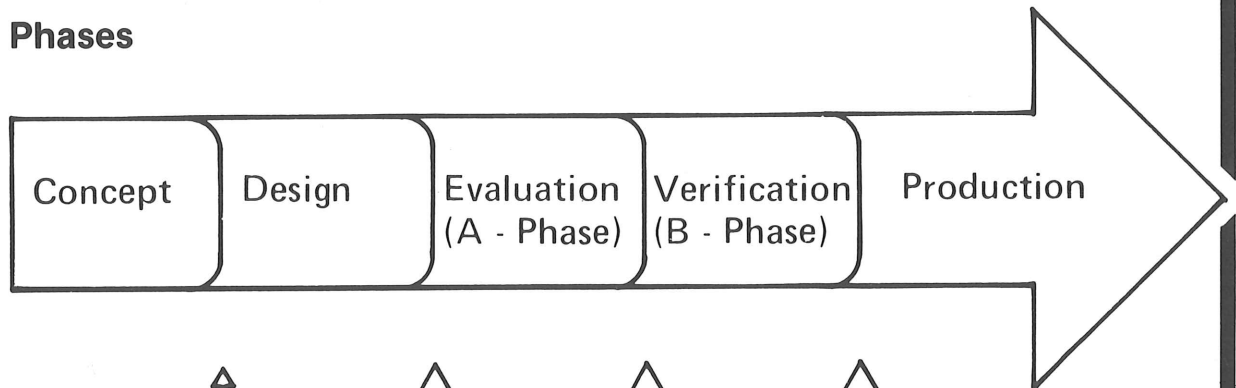
The NPI Guidebook provides details on each phase. The guidebook was written for project managers and is being distributed throughout the divisions and support areas.

If your manager doesn't yet have a copy of the guidebook, you can take a look at one of the two copies in the library.

—Gary Graham  
ext. 5851



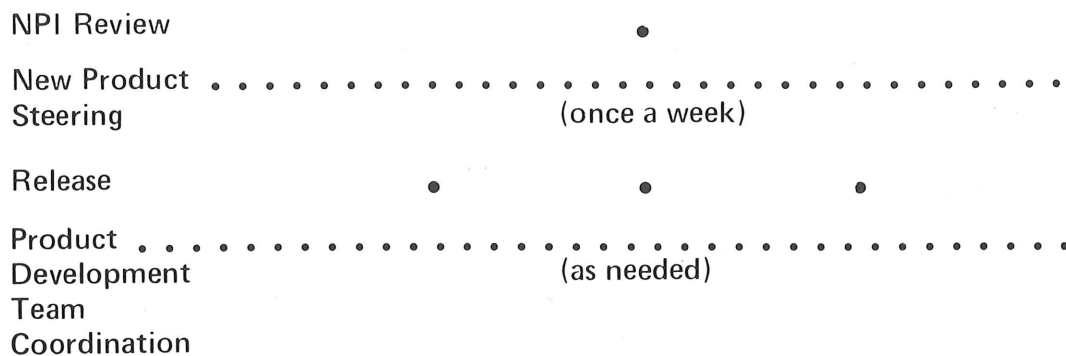
## Phases



## Milestones



## Meetings



The process of introducing a new product to the market has five phases. The completion of each phase is marked by a milestone. Meetings of representatives of all the groups involved encourage communication and coordinated planning.

## TEKTRONIX GPIB POLICY

*At the present time there are over 200 instruments that utilize the IEEE 488 interface commonly known as the GPIB. In order to remain competitive in this programmable instrumentation market, Tektronix instruments will also use the GPIB interface wherever it is appropriate and practical.*

*In order to utilize the GPIB effectively, coordination of our efforts is necessary to:*

- 1) Make our instruments compatible with each other and avoid duplication of effort in areas such as design, programming and maintenance of GPIB instruments.*
- 2) Present a unified voice in the setting of reasonable national and international GPIB standards as they evolve.*
- 3) Facilitate the implementation of existing national and international standards that already exist.*

*The above GPIB coordination tasks will be carried out by the Tektronix corporate interface engineer. As part of this job, he will be responsible for both internally used GPIB standards and represent Tektronix in the establishment of national and international GPIB standards.*

*March 7, 1977*

**Bill Walker**

**Larry Mayhew**

## THE CORPORATE INTERFACE ENGINEER

Responsibility for implementing the Tektronix general purpose interface bus (GPIB) policy means class work, committee work, and information management for Maris Graube, the Tektronix corporate interface engineer.

### GPIB CLASS

Maris is teaching a GPIB class for instrument designers. The class is addressed to two general problems

- designing for the GPIB, and
- providing the background that's needed to fully understand the GPIB specification (IEEE-488).

### USERS GROUP

Maris also participates in a GPIB instrument users group which meets to discuss the problems of implementing GPIB with programmable instrument systems. The users group meets every Wednesday at 8 am in conference room A in building 58. First-time GPIB users get an opportunity to talk to others who have already been through the mill.

### CODES AND FORMAT COMMITTEE

A third task for the corporate interface engineer is chairing a committee (with representatives from all over the company) that seeks to standardize Tektronix use of data codes and formats for the GPIB. The use of standardized codes and formats will make Tektronix instruments more compatible with each other, as well as easier to use.

### A DATA FILE

Another implementation of the Tektronix GPIB policy is the maintenance of a file on Tektronix experience with GPIB. The file includes schematics of GPIB designs and operation manuals of GPIB instruments from all manufacturers.

### FOR MORE INFORMATION

For more information on GPIB activities at Tektronix, call Maris at ext. 6234, or drop by 50-454.

# CHANGES IN ETCHED CIRCUIT SUPPORT

Major changes have been made in Etched Circuit Support's organization and procedures to help meet the rising demand for high-quality boards with fast turn-around.

**Electrochemical Engineering Support** has been added to Etched Circuit Support's other functions (Etched Circuit Standards and Supplies, Precision Graphics, the CAD system and the Etched Circuit Prototype Lab).

Wally Doeling is now the manager of Etched Circuit Support, Precision Graphics and Electrochem Engineering. Tino Ornelas, a member of Wally's staff, will be liaison between Etched Circuit Support and the product groups. Dave Davis, who reports to Wally, is manager of Etched Circuit Standards and Supplies, the CAD system, and the Etched Circuit Prototype Lab. Besides reorganizing, Etched Circuit Support will be adding new equipment to raise etched circuit board quality and reduce turn-around time. The new equipment will include a new drilling machine and new plating lines.

## QUICK BOARDS

To make its operation more efficient, Etched Circuit Support has asked its customers to categorize the boards brought to them for processing. Quick boards will have the fastest turn-around. For two-sided boards the turn-around time will be 24 hours, and for multilayers it will be 48 hours. No more than 1000 drill holes will be drilled unless the order is accompanied by CAD tapes, and there can be no more than four drill changes. An order is limited to two boards.

The laminate for quick boards will be the standard FR-4 glass epoxy. Plating will be either class A, B, C, or H (as defined in the Tektronix Standards 062-1723-00 and 062-1727-00). Quick boards won't receive any tip plating on the edge connector, silk screening, or solder masking.

## PROTOTYPE BOARDS

These boards will be processed within three working days if they're two-sided, or four working days if they're multilayers. (A working day is any 24 hour period excluding Saturdays and Sundays). Two to four boards may be ordered. The laminate will be the standard FR-4 glass epoxy, and the plating will be class A, B, C, or H. Tip-plating of edge connectors, silk screening, and solder masking may be used.

## MULTIPLE BOARDS

This category includes A-phase and B-phase boards in quantities of 5 to 50. Turn-around time is two to four weeks as long as the etched circuit lab is processing boards in building 50, but it will be two weeks when the quick-board line is completed in building 38. When the lab is overloaded with orders, boards can be farmed out (boards made outside will meet Tektronix standards).

## SPECIAL BOARDS

Boards that need special material (such as Kapton or Teflon), or special processing, fall into this category. Examples of special requirements are special plating thicknesses, pin guide boards, special silk screening or solder masking, special material for multilayers, and unusual drilling requirements.

With the artwork and order in hand, etched circuit lab can negotiate the turn-around time.

## MORE INFORMATION?

If you need more information, call Tino Ornelas, or Wally Doeling on ext. 6581, or ext. 6236 or drop by 50-116.

Turn  
Around  
Time

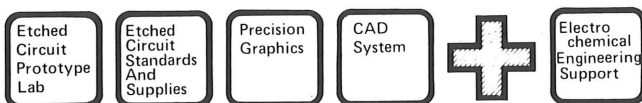
Special Boards  
(negotiable)

Multiple Boards

Prototype Boards

Quick Boards

**Etched Circuit Board Support, to make its operation more efficient, is now asking its customers to categorize the boards it is processing.**



**Electrochemical Engineering Support has now been added to Etched Circuit Support's other functions. The addition of Electrochem Engineering Support is one of the steps Etched Circuit Support is taking to help meet the rising demand for high-quality, fast-turnaround etched circuit boards.**

# THE FINAL EXAM

In this age of intense specialization, there are times when it is refreshing to step back from the rush of our technological world and review our basic skills and knowledge.

The following quiz is a quick and easy way to check your grasp of life's basics. Originally the quiz was a final exam for system analysts, but its general applicability is obvious.

The ultimate source of the exam isn't known. It was one among many items of mail in the plain-brown-wrapper-no-return-address category George Rotsky (Editor-in-Chief of **Electronic Design**) receives each month. Our gratitude goes to George for passing on this stimulating exercise.

**INSTRUCTIONS:** *Read each question carefully. Answer all questions. Time limit is four (4) hours. Begin immediately.*

**HISTORY:** *Describe the history of the Papacy from its origin to the present, concentrating especially, but not exclusively, on its social, political, economic, religious and philosophical impact on Europe, Asia, America and Africa. Be brief, concise and specific.*

**MEDICINE:** *You have been provided with a razor blade, a piece of gauze and a bottle of Scotch. Remove your appendix. Do not suture until your work has been inspected. Allow yourself no more than five (5) minutes for this.*

**PUBLIC SPEAKING:** *Approximately 2500 riot-crazed aborigines will soon be storming the classroom. Calm them. You may use any ancient language except Latin or Greek.*

**BIOLOGY:** *Create life. Estimate the differences in subsequent human culture if this life form had developed 300 million years earlier, with special attention to its probable effect on the English Parliamentary system. Prove your thesis.*

**MUSIC:** *Write a piano concerto. Orchestrate and perform it with flute and drums. You will find a piano under your seat.*

**PSYCHOLOGY:** *Based on your knowledge of their works, evaluate the emotional stability, degree of adjustment, and repressed frustrations of each of the following: Alexander of Aphrodisias, Rameses II, Gregory of Nica, and Hammurabi. Support your evaluation with quotations from each man's work, making appropriate references. It is not necessary to translate.*

**SOCIOLOGY:** *Estimate the sociological problems that might accompany the end of the world. You may construct an experiment to test your theory.*

**ENGINEERING:** *The disassembled parts of a high-powered rifle have been placed on your desk. You will also find an instruction manual written in Swahili. In ten (10) minutes a hungry Bengal tiger will be admitted to the room. Take whatever action you feel appropriate. Be prepared to justify whatever decision you make.*

**ECONOMICS:** *Develop a realistic plan for refinancing the national debt. Trace the possible effects of your plan in the following areas: cubism, the donatist controversy, the wave theory of light. Outline one plan for eliminating these effects. Point out the deficiencies in your point of view, as demonstrated in your answer to the latter part of this problem.*

**POLITICAL SCIENCE:** *There is a red telephone on the desk next to you. Start World War III. Report at length on its socio-political effects, if any.*

**EPISTEMOLOGY:** *Take a position for or against truth. Prove its validity.*

**PHYSICS:** *Explain the nature of matter. Include in your answer an evaluation of the impact of the development of mathematics on science.*

**GENERAL KNOWLEDGE:** *Describe in detail. Be objective and specific.*