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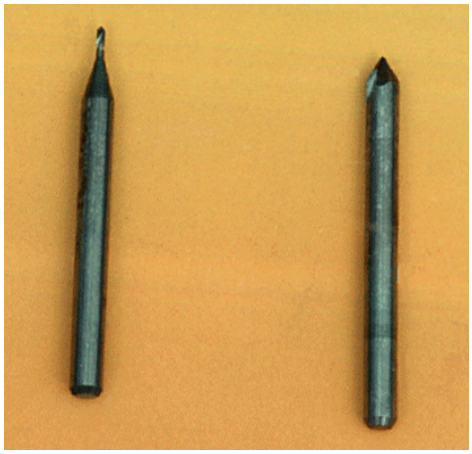
New tooling

T-Tech has undertaken a significant development program on milling tools, resulting in the release of the T8 tool. With an angle of approximately 90°, this tool is recommended for cutting from 0.008" to 0.012" spaces (0.2mm - 0.3mm), and has a rated life of 7500 linear inches, compared to 2500 for the old T1 tool, which is no longer available. For those of you who have used our earlier Ultramill tools (no longer stocked), this tool is similar in appearance, but so much better in performance and wear characteristics!

T-Tech has also announced the release of the T4, a tool of similar design to the T8, but with a finer point, suitable for cutting down to 0.006" (0.15mm) and smaller spaces. Rather delicate, and a bit more expensive than the T8, these tools are specifically intended for particularly fine work.

As a general purpose 0.010"-0.015" (0.25mm-0.4mm) workhorse, the T3 will continue to be produced and stocked. As well as being ideal for those who prefer a tool that really looks like it is up to the job, these tools are just the thing if you need to make snap-apart Vee-grooved (scored) panels!



T8 / T4 **T3**

Extended range of tools

In recognition of the amount of microwave prototyping work being done by our Quick Circuit users, we now maintain a comprehensive range of end mills from 0.005" to 0.125" (0.127mm to 3.175mm). Being of American origin, end mills are imperial sized. Full details are shown in the enclosed price list.

Chuck screwdriver

We've had these for a while now, but some of you may not have seen them yet: a screwdriver-handled 1/16" Allen driver for the chuck - easier to use, harder to lose! A must at only $12.

Backup material & entry foil

We have added 3.2mm (1/8") backup board to our stock list, and presently have good stocks for those who prefer this to using two thicknesses of the 1.6mm "industry-standard" material we have offered up to date. From now on, 3.2mm will be our "normal" material - if you particularly want 1.6mm, please specify. We also have quantities of self adhesive coated (one side only) backup material. This is intended for use with thin, soft and flexible laminates (typically Teflon/Duroid), and it helps to hold the laminate down to the backup while milling. If you are using these soft thin materials, ask for a sample: - we'd like your feedback. Recognising that this material will not be used as much as normal backup board, we are selling it in packs of four, rather than eight pieces.

We have also added entry foil material to our price list. Entry foil is virtually obligatory for drilling holes smaller than 0.5mm, and improves drill registration accuracy for hole sizes up to about 0.8mm. Available in both self-adhesive and plain.

Software: - current versions, updates etc

Current versions of software are always available from T-Tech's website (www.t-tech.com), and at the date of this publication are as follows:

Isolator	(DOS)	ver 3.2.1
	(Windows)	ver 3.3
IsoPro (Win'95/NT only)		ver 1.12 Build 58
QuickCAM	(DOS Opti-Step)	ver 4.02
	(DOS serial)	ver 1.08
	(Windows)	ver 2.1k (currently being shipped with new systems)
	or	ver 3.2 (recommended for Win'95 or NT users)

Most software can be downloaded from T-Tech's website or FTP site, or is available by phoning SATCAM. We are happy to supply diskettes, but a distribution charge will apply.

T-Tech's software policy for is that upgrades are available at no charge forever. Keep an eye on the website if you want to keep up to date (but remember that beta versions are not guaranteed against bugs …).

If you upgrade your *QuickCAM* for Windows, remember to make a note of your X_HOME and Y_HOME values from your CAM.INI file, as this file may be overwritten during the upgrade installation. Also, there have been some unconfirmed reports of an apparent incompatibility between *QuickCAM* for Windows ver 2.1k and the firmware of the model 7000 controllers (serial numbers SB-xxxx). If you try 2.1k and have a problem initialising your machine, try pressing the E-STOP button, revert to ver 2.1i, or move up to ver 3.2.

The policy for *Isolator* is that you can use any version of *Isolator* which has an executable date which is earlier than your key date (when you bought your system, your key date was about twelve months in the future, giving you access to new software for that period). If you want to use code which is newer than your key date, you'll need to get a key refresher update, available for $1000. This will bring you up to date, plus twelve months. It also gets you access to the all-new 32 bit *IsoPro* package (see below).

How do I check my key date? Early versions of *Isolator* display the version, key serial number and key date as part of the program launch process. In later versions, this information is accessed through the typical Windows mechanism of About|Version Information.

IsoPro… T-Tech has bought the intellectual property comprising *Isolator* from GraphiCode Inc, and in parallel, has produced a completely new 32-bit software product called *IsoPro*. As a true 32-bit application, *IsoPro* requires Win'95 or Windows NT, and is a significant evolutionary step from *Isolator*. If your key date is 14 May 1997 or later, you can download the full version from T-Tech's website, and run it. A demo version is also available from the website for evaluation by customers with older keys.

Among the new features is a "remove redundant" command which allows multi-pass isolation without the time-wasting tedium of watching a small (=expensive) end mill go over paths which have already been cut out with a larger tool. Also attractive is the ability to specify multiple isolation widths in one isolation pass, just by filling in the various sizes of tool you wish to use - takes a lot of the tedium out of it! Other improvements include easy layer registration, intelligent rub-out, unlimited undo, and board material management system. As well as all this (and more), a DXF import capability is available as an option for just $1000.

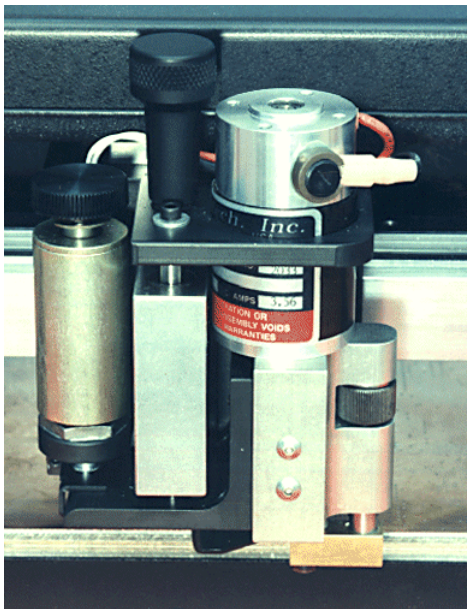
IsoPro vs *Isolator* feature table

FEATURE	*Isolator*	*IsoPro*	COMMENTS
Current version	3.3	1.12	Build 58
Upgrade available	X	X	From *Isolator* x.x to *IsoPro*
Run on *Isolator* key	X	X	
Run on *IsoPro* key		X	
Windows 3.1	X		
Windows '95	X	X	
Windows NT	X	X	
Windows Network		X	Requires special key
Import Gerber	X	X	
Import HPGL	X		*IsoPro* can read simple HPGL-1 files
Import DXF		X	Optional key update
Import Excellon	X	X	NC drill
Import CWK	X	X	Current *Isolator* format
Import PWK	X	X	Old *Isolator* format
Load ISO		X	*IsoPro* format
AutoImport	X	X	
Import helper		X	Hints on size of board
Multiformat input per file		X	
Multiple isolation		X	Multipass with one click
Remove redundant		X	
Text edit	X	X	
MRC/clearance check	X	X	Old *Isolator* called DRC
Create pads/traces	X	X	
Metric/Imperial button		X	
Invisible apertures	X		
Auto board outline		X	Time-saver
Polygon handling	X	X	Mainly for AutoCAD DXF
Multiple rubout		X	Rubout multiple areas on one layer
Unlimited rubout overlap		X	*Isolator* maximum 50%
View - ball/normal/transp	X	X	
Pan view		X	
Board management		X	Best use of available board material
Help menu		X	
Unlimited undo		X	*Isolator* has only last command undo
Multiple drill/apt tables	X	X	
Scaling		X	

EagleWare/Genesys/Quick Filter microwave design software

T-Tech has established a link with Atlanta-based microwave design software company Eagleware, and although SATCAM does not (as yet) have any form of agreement with Eagleware, we would be pleased to pass on brochures and other information to anyone looking for some powerful new RF/microwave design tools offering guaranteed compatibility with the QuickCircuit system. A copy of a filter design performed by T-Tech using their software is included with this mailing.

Head adjustments made easy



Tired of using a giant screwdriver and pair of long-nosed pliers (American spanner!) to adjust the solenoid plunger? Just gone to adjust the top stop nut and found someone's nicked the spintite? The answer is at hand! Priced at just $90, the head adjustment knob kit does away with all the loose tools, and replaces them with a set of knurled knobs. Once you've tried it, you'd never go back!

Through-hole connectivity

Harwin Via-pins

Our recommendation as the quickest and simplest way of achieving through-hole connection as long as you don't need a hole through it (vias only). 50 flat-headed slightly tapered 0.85mm pins in a string go into a hand-held tool. You move the first pin forward, push it into the hole in the board, break it off, and proceed to the next one. Solder both sides. The component side is reasonably flat, the wiring side has a bit of pin protruding. Designed for 1.6mm material, but okay for thinner, as long as you don't mind a bit of extra overhang on the wiring side. Drill 0.85mm. Cheap, cheerful and very speedy! Material cost is $0.05 per hole.

Copperset

Arguably the best way to achieve small-to-medium quantities of hollow through hole-connections, this is an economical, but a slightly tedious one-at-a-time manual system for 1.6mm material only. A bail-bar containing 25 bails is placed in a hand-held inserter. The first bail is slid out, pushed through the board and carefully broken off. The board is placed on a flat surface (*Quick Circuit* machine bed), and the bail is expanded into the hole with a spring-loaded hand-held punch rather like an automatic centre-punch. The bail consists of a thin shell of copper over a core of solder. Suck out the solder with a capillary wick product (included in the kit) or a solder-sucker, and you have a good quality "plated-through" hole. The kit contains tooling for three sizes of bail, 0.8mm, 1.0mm and 1.2mm, and 20 bailbars (500 bails) of each size. A very good result, once you've had a bit of practice. We recommend drilling 0.85, 1.05 or 1.25mm holes for a snug fit (don't worry about using the "reamer" supplied with the kit). Material cost: $0.05 per hole.

Quick Connect

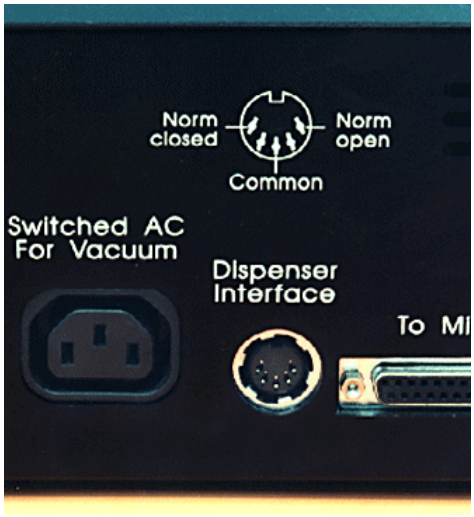
T-Tech's first process for automated connectivity, *Quick Connect* uses the *QuickCircuit* machine to inject a metered amount of conductive epoxy into the required holes. The panel is carefully removed from the milling table, and the epoxy is cured in an oven (infra-red or convection). For vias which can remain solid, this is all that is necessary. For hollow through-holes, you should have drilled the holes slightly (0.010"/0.25mm) oversize before you squirted the goo into them. Then, after thermal curing, you put the panel back on the milling table and do a second stage drill at the final size, to leave a thin shell of cured conductive epoxy down the hole. Typical through-hole resistance is about 50 milliohms. Still a bit fiddly, but capable of a very good result. There is enough silver-plated copper in the goo (about 85%) to assure easy solderability. Recommended for boards with a lot of PTHs (we feel it's not really worth getting it set up for fewer than a couple of hundred holes). Needs an oven, a compressed air supply, and refrigeration between uses for the paste. Material cost is about $0.15 per "average" hole.

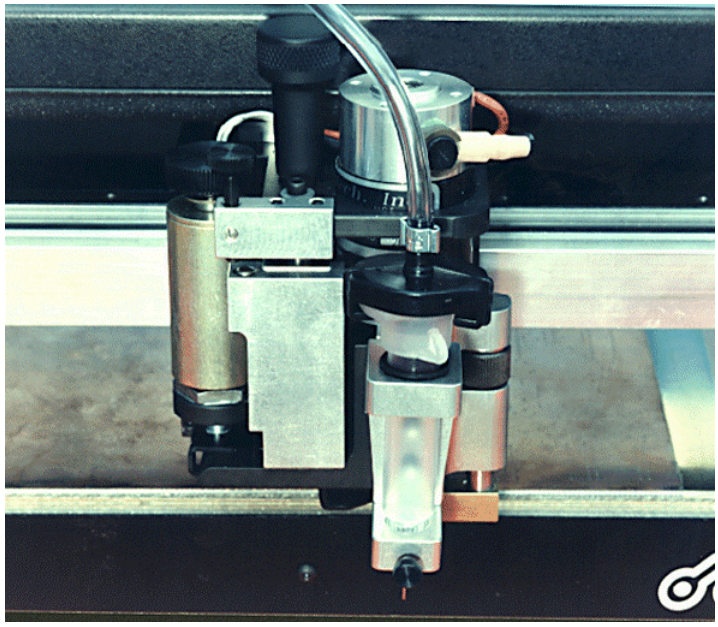
Quick Plate

Brand new release (this month), so details are still sketchy. A genuine electroplating system complete with plating and rinse tanks to accommodate 18" x 12" (450mm x 300mm) panels, and 40A power supply. Budgetary price is about $13,000. More details should be available by the time you read this - if interested, call SATCAM, or check T-Tech's website (www.t-tech.com/mlayer). You will also find some preliminary news there about T-Tech's multilayer capability!

Dispensing System

If you want to deposit some sort of goo onto/into your boards, T-Tech can help! Principally intended for depositing conductive epoxy into holes for through-hole conductivity (see previous page), the *Quick Connect* system will also allow you to deposit solder paste or adhesive for SMT, or even draw a component legend. As long as your present controller has a Dispenser Interface connector on its rear panel (see photo), $3750 will buy you the pneumatic controller/interface and extended software for depositing goo on your boards. If you don't have the connector on your controller, then you're up for a new controller as well ($4500, see below: "New Products/Hardware Upgrades").





New price list

As well as suffering the imposition of a 3% import duty during 1996 (recently increased to 5% for replacement parts), I guess we've all seen what has happened to the Aussie dollar in the last twelve months. As a consequence of this, we've re-arranged some of our supply channels, and although some tool prices have increased, others have actually decreased. A copy of the new price list is enclosed, please use this as your buying guide until further notice.

Changes to pricing policy

First the bad news:

Let's be blunt about it, small-value orders are relatively expensive to process, particularly when export paperwork is required. As a reflection of the costs incurred in packing, processing and paperwork, "small" orders (less than $100 net value excluding freight) will attract a new handling charge of $35, effective 1 April 1998. We trust you will understand that this is a simple reflection of the fixed costs of inventory control, paperwork and packaging, and we see it as a better option than the alternative of simply refusing to accept low-value orders.

Now the good news:

Freight pricing policy

Freight pricing policy remains unchanged, with small consignments being charged at $15 for overnight airfreight anywhere in Australia, or $35 for New Zealand. Heavier consignments (eg board material) are naturally dearer.

Copies of T-Tech News

Over the last few years, T-Tech has produced a number of issues of their newsletter "T-Tech News". These contain a variety of information, some relevant, some not so, and we have included a copy of each of these with this bulletin in the hope that you may derive something useful from them. Just remember that prices are US dollars (and out-of-date), and that special offers no longer apply.

New products and hardware upgrades

All systems (both Models 5000 and 7000) shipped December 1997 and later have a revised head assembly with a new brushless dc motor offering the same speed range as before (8,000 - 23,000 rpm), but a larger Z-axis work area of up to 16mm (previously about 6.5mm) to allow thicker material to be milled or engraved. The introduction of the brushless motor also offers longer motor life, with less maintenance.

T-Tech has also announced a new high speed (up to 60,000 rpm) spindle option, using a high-frequency brushless motor, and equipped with a tool-less collet chuck for easier tool changing. This option is available now on new 5000 and 7000 systems, but not for retrofit to machines produced prior to 1998. 1998 machines delivered with the new standard 23,000 rpm head can be upgraded to 60,000 rpm at a later date if desired.

Although neither of these improvements is available for retrofit, we are always prepared to discuss trade-ins of old systems for new, as we frequently have enquiries about the availability of second-hand/reconditioned systems.

For users of older machines employing the OptiStep parallel interface, we are able to offer an upgrade to the AMC2500 "Advanced Motion Controller". This controller has an RS-232-C serial interface and includes software-controlled variable spindle speed (8,000 - 23,000 rpm). Upgrade cost is only $4500 for machines fitted with 24V spindle motors, or $7500 including a new 24V head for users of earlier machines fitted with 5.6V motors. This upgrade allows the use of *QuickCAM* for Windows with the ability to move and mirror (flip) files at the machine level as an alternative/supplement to doing this in *Isolator*, as well as improved ability to select and mill individual nets or windowed areas of a job. These controllers also provide the necessary interface to drive the deposition controller used for QuickConnect through-hole deposition, solder paste and adhesive placement.

Technical Support

User Guide

Some users will already have seen SATCAM's attempt at a User Guide or "how to do it" manual. We have tried to keep it simple, as a step-by-step process all the way from your design software through to cutting out the finished board. If you'd like a copy (about eight A4 pages), just call us.

Telephone

We believe we know most of the answers to day-to-day problems (not all of them, unfortunately), and are always prepared to help with phone support where we can. Within sensible limits, this service is available at no charge. If your needs are more extensive (eg introduction or full training for a new user) either by phone or in person, we would be pleased to discuss this on a fee-for-service basis.

Video

T-Tech has finally started to produce some training videos, which are available for purchase. Topics covered so far are *IsoPro*, Quick Circuit machine operation, and use of *Quick Connect* through-hole deposition. If you feel any of these may be of assistance, please call SATCAM.

Technical Tips

Use of feeler gauges

If you're using end mills, you should be using feeler gauges. Feeler gauges take the "cut-and-try" out of depth setting, and save a lot of time and a lot of cussing. **Method 1:** Just gently press the head down by hand until the tip of the tool is touching the board surface, then adjust the pressure foot knurl nut until the appropriate feeler gauge is a snug fit between the pressure foot and the board surface. **Method 2:** With very small end mills, it may be preferable to adjust the knurl nut so the tool is close to the board surface when the pressure foot is pressed down to touch the surface, then press the head down with the the feeler gauge under the pressure foot, open the chuck and allow the tool to drop to the material surface, then tighten chuck. The most common laminates are 35um (1oz) or 18um (½oz) copper, which are 0.0014" / 0.0007" thick, so a 0.0015" feeler is a good choice.

Remember that soft substrates like PTFE tend to be compressed by the pressure foot, sometimes resulting in a deeper cut than expected.

Feed rates

A copy of T-Tech's recommendations for tool feed rates is included as Appendix A to this newsletter. The overall position is obvious - small tools are expensive, fragile and need to be run more slowly than larger tools. If you are making high frequency boards where small radii are essential, consider an upgrade to *IsoPro*, to take advantage of the "remove redundant" feature to minimise the use of small tools. Also consider the use of a less expensive T8 tool to remove some of the copper before doing a finishing pass with the very small end mill. In general, it is probably better to use larger tools first, smaller tools later, when there is less material to remove.

Material storage

Although the pressure foot compensates for most minor bumps in the pcb laminate, it will not accommodate severe bends or deformations, particularly if you are milling fine detail designs. Pcb and backup board material should always be stored flat, and should never be left leaning against a wall. Before you start each job, place the pcb laminate and the backup board (separately) on the machine bed, and check for flatness - because of its inherent asymmetry, single-sided laminate will almost always be "cupped". Gentle hand force should be used to flatten the material before you pin and tape it to the bed.

Speaking of the pressure foot, you probably assume that it has an infinite lifetime, just riding gently over the nice smooth copper surface. Wrong! Although it is made from some sort of hardened and polished steel, the radius button on the pressure foot (the bit which runs on the surface of the board) will eventually wear flat. This can give rise to entrapment of swarf (causing scratches and uneven depth-of-cut) and increased drag on the X-Y stepper motors (possibly causing positional errors). Complete replacement pressure foot assemblies are available for only $85, while replacement radius buttons are a mere $10 (not available for older machines - check with SATCAM).

What size end mill should I use for copper rub-outs?

Bear in mind that for most "typical" boards with reasonable track density, the majority of the time taken to perform rub-outs is involved in stopping, jumping over tracks, and starting again. This observation suggests that for a board with 0.010" minimum clearance, it may be quicker to perform three Isolation steps at say 0.010", 0.020" and 0.040" followed by a rub-out at 0.040", than to do just two Isolations of 0.010" and 0.020" followed by a 0.020" rub-out. It is also significant that larger end mills are, in general, less expensive than smaller ones.

Always perform rub-out (fill) with the same sized tool used for the largest Isolation, and specify this Isolation layer as the reference layer for the fill operation (this process is taken care of automatically in *IsoPro*).

With the availability of the "remove redundant" feature of *IsoPro*, it makes even more sense to perform multiple Isolation passes leading up to a large rub-out tool. Remember also that *IsoPro* allows you to window multiple areas for rubout within the same layer.

In what order should I do my Isolations (in *Isolator* and on the machine)?

Armed with the knowledge that larger end mills are less expensive than smaller ones, it seems sensible to use larger tools to provide most of the cutting effort. This suggests that in the previous example of a board with minimum clearance of 0.010", we should start with the 0.040" Isolation, then 0.020", then 0.010" (probably using a T8 tapered tool), then go back to 0.040" to do the rub-out (if demanded by the application).

If you are not using *IsoPro*, the display of subsequent Isolation steps in *Isolator* can be better visualised by doing the larger Isolations first, eg 0.040", 0.020" then 0.010". This means the smaller cuts will be displayed on top of the larger cuts, rather than obscured by them.

Broken tools and head adjustments

Our most frequent enquiry for tech support usually starts with "I'm breaking a lot of tools…"

There are a number of possible causes for this, but we usually slip it into the conversation somewhere that at SATCAM we make stacks of boards for a range of purposes, and while we have quite a collection of worn-out tools, we have very few breakages.

Tools tend to break for two separate reasons - higher-than-normal lateral (sideways) loading exceeding the elastic modulus of the tool material; and stress-induced micro-cracks in the grain structure of the tool producing localised weaknesses.

Excessive lateral load can be caused by too high a feed rate; too great a depth of cut; too slow a spindle speed causing swarf to clog the tool; or simply because the tool is blunt, and can't cut the material away in front of itself. For guidance on feed rates, see T-Tech's feed rate recommendations reproduced in Appendix A. The rates are given for guidance only, and with experience, you will probably find that they can safely be exceeded, as long as all the caveats mentioned here are observed.

Stress cracking is most frequently a result of excessive "head-up" clearance between the tool tip and the surface of the circuit board. This allows the head to accelerate too much, and the head to gain too much momentum before the tool hits the circuit board surface. T-Tech recommends 1/16" (1.6mm) clearance - we suggest trying to get it down to 0.5mm (0.020"), but it's really just a case of "less is better". The downside to minimising this clearance is that if your work material has bumps which are higher than the clearance, the tool will cut the surface of the board when it is supposed to be clear of it, usually destroying your board! The obvious answer to this (see above: "Material storage") is to ensure the absolute flatness of your material before you start, and to check it during the job, if it is a long job. You should also do a clearance check near the centre of your job, and not just at the home position. A full dissertation on head adjustments is included as Appendix B to this newsletter.

Uneven cutting depth

Possible causes include:

- insufficient downward force on tool due to incorrect solenoid adjustment (usually when using end mills) - see Appendix B for adjustment details;
- blunt tool;
- spindle speed too low relative to feed rate (or feed rate too high for spindle speed);
- fine swarf build-up under pressure foot, frequently caused by reduced air flow due to vacuum bag being over-due for an empty! For consistent clean cutting, the need for good vacuum air flow cannot be over-emphasised.

Corrosion protection

To prevent your boards corroding, and to ensure easy solderability, we recommend Electrolube CPL200H, an aerosol clear protective lacquer. Quick drying (handle carefully in about 20 mins, hard dry in about 6 hours, maximum mechanical properties in 24 hours) and able to be soldered through, this spray will keep boards bright and solderable for months. ***To avoid the dip tube in the can becoming clogged when you haven't shaken it quite long enough, we strongly recommend storing the cans upside-down (cap down).*** A brilliant finish for only $12 a 200ml aerosol can.

Spraying can be done either before or after you have de-panelled your board. For double-sided boards, or in cases where you a making a quantity of boards on a panel at once, it is probably easier to spray the complete panel. Support the panel by the corners to spray the second side, let the lacquer harden (slightly elevated temperature will speed this up), put it back on the machine and run the contour rout plot file to de-panel. We suggest either of the following approaches to avoid damaging the lacquer finish with the pressure foot:

- set the pressure foot high enough to clear the surface of the board completely, and use the solenoid adjustment to control the penetration depth. If you use this approach, you'll need to ensure that the pcb and backup are really flat, and allow enough cut depth to ensure that you cut right through all over the job. You may find the pcb material tends to be lifted off the backup board by the helix structure of the contour router tool, and you may need to apply careful hand pressure to hold the boards down as they are being cut.

- Use the normal technique of pressure foot depth control, but with a sheet of entry material pinned on top of the board to protect the surface from the pressure foot. You will, of course, end up with a cut out piece of entry material corresponding to each pcb you cut out.

If you use this technique on a board which has copper right to the edges (either ground planed by design, or simply not subjected to a copper rub-out), you will have an exposed (unlacquered) copper edge around the board. This may be avoided by creating a pair of layers (one for each side) which follow the exact profile of the pcb (not offset for tool compensation like the contour rout), and using a T3 tool to make a V cut through the copper and into the fibreglass substrate (cutting depth about 0.010"/0.25mm) before spraying. This will provide a lacquer-coated slight chamfer to the finished boards.

Component legends

If you are making single sided boards, you can engrave your component legend. In *Isolator*, simply load your component legend Gerber file normally, then change it from an aperture to a tooling file, and use ctrl-N to assign all lines the same tool size (something about 0.012"/0.3mm). Save the resulting file, and engrave with an appropriate tool (a blunt T8 is good). For the legend to be clearly legible, the character height should be set to at least 0.060"/1.5mm in your EDA software (6:1 is a good ratio for character height:line thickness). If you really want to get carried away, you can paint-fill the characters (but do the legend/paint fill as the very first step, before drilling).

If you have a *Quick Connect* system, you can even put ink/paint in the syringe and dispense the legend. Obviously this is not limited to single sided boards.

Big holes

Don't forget that if your design has lots of larger holes (say >0.060"/1.5mm), you can use a contour router tool rather than big drills. Typically you might have a few of each of a number of different sizes, which would make for lots of rather boring tool-changes. Current versions of *QuickCAM* for Windows allow you to specify the router size once, and then proceed to rout all remaining large holes automatically.

Routing soft materials

Standard contour router bits are designed for hard materials like FR4, and tend to tear soft materials like Teflon, producing a rather ragged finish. To achieve clean cutting of these materials, try using an end mill tool instead of the contour / profile router.

Appendix A - Recommended Feed Rates

(courtesy T-Tech Inc), inches per minute

Note that the "traverse rate" can be set to 60 inches per minute for all procedures, but remember that if you perform a "Relative Move" or "Absolute Move", these will be performed at the traverse rate. BE CAREFUL if you use these functions for doing test cuts…

End Mills	**18um (½oz) Cu**	**35um (1oz) Cu**
0.005" (0.127mm)*	2	1
0.008" (0.2mm)*	5	3
0010" (0.25mm)	15	10
0.012" (0.3mm)	20	15
0.015" (0.38mm)	30	20
0.020" (0.5mm)	45	35
0.0312" (0.8mm)	60	60
0.050" (1.27mm)	60	60
0.125" (3.175mm)	60	60

* You will achieve better tool life if you score first with a T8 tool to remove some of the copper

T8 Tools

0.004" to 0.006" (0.1mm to 0.15mm)	45	30
0.007" to 0.012" (0.15mm to 0.3mm)	60	35

T4 Tools

0.004" to 0.006" (0.1mm to 0.15mm)	5	2

T3 Tools

0.008" to 0.010" (0.2mm to 0.25mm)	45	35
0.011" to 0.013" (0.25mm to 0.3mm)	55	45

Contour Routers (1.6mm FR4 fibreglass)

1.0mm	15-20
2.0mm	25

Appendix B - Head Adjustments

(courtesy T-Tech Inc)

The solenoid provides power to produce the downward motion of the head assembly. The solenoid has an exponential power curve, ie as the plunger moves into the solenoid coil, its force increases exponentially. When the plunger is positioned high out of the coil assembly, the force is relatively weak, and when the plunger is fully within the coil assembly, the force is at its maximum.

When a milling tool is cutting the copper, it needs the proper amount of force in order to make a smooth and consistent cut, so it is important to make sure that the solenoid is adjusted correctly. Two things can happen if it is adjusted incorrectly:

1 If the plunger is too high, the tool may not have enough downward force to cut the copper properly, resulting in uneven or "skipped" cuts

2 If the plunger is set too low, the tool may not have enough Z-axis travel to mill or drill to the correct depth (cutting depth becomes controlled by the plunger in the solenoid rather than the pressure foot on the pcb material)

How to adjust the solenoid (older models need large screwdriver and pliers/spanner)

1 Grip lock nut with spanner/pliers

2 Using screwdriver, turn plunger clockwise to increase power

3 You will observe that this reduces overall Z-axis travel of the head

With newer models, just turn the solenoid plunger knob clockwise to increase power (see "Head adjustments made easy", p3).

Reasons for greater power:

1 Increased consistency of end-milled cut quality

2 Helps when tool is not sharp

3 Helps with large drills and end mills

Reasons for less power:

When using very small end mills, less downward force can help prevent tool breakage. This also applies to very small drills (<0.5mm), and possibly to T8 and T3 tools. In general, the larger the drill or end mill, the closer the plunger should be, the smaller the tool, the greater the plunger gap.

Note: Always check to make sure there is enough Z-axis travel available to allow the drill to fully penetrate the material, or the milling tools to remove the copper. If the plunger is bottomed out on the solenoid body, it will not allow proper downward positioning of the head assembly, resulting in uneven cutting. SATCAM's recommendation is to make sure there is never less than about 0.5mm clear gap between the adjusting knob (or the circlip in older models) and the top of the solenoid body.

Tool & material price list

1 JANUARY, 1999

QUANTITY	DESCRIPTION	PRICE
CARBIDE DRILL BITS		
pk. of 5	drill bits, 0.25mm	$ 100.00
pk. of 5	drill bits, 0.35mm	$ 40.00
pk. of 5	drill bits, 0.40mm	$ 40.00
pk. of 5	drill bits, 0.45mm	$ 40.00
pk. of 5	drill bits, 0.50mm	$ 30.00
pk. of 5	drill bits, 0.60mm	$ 30.00
pk. of 5	drill bits, 0.70mm	$ 30.00
pk. of 5	drill bits, 0.80mm	$ 30.00
pk. of 5	drill bits, 0.85mm (for 0.8mm Copperset pins and via pins)	$ 30.00
pk. of 5	drill bits, 0.90mm	$ 30.00
pk. of 5	drill bits, 1.00mm	$ 30.00
pk. of 5	drill bits, 1.05mm (for 1.0mm Copperset pins)	$ 30.00
pk. of 5	drill bits, 1.10mm	$ 30.00
pk. of 5	drill bits, 1.20mm	$ 30.00
pk. of 5	drill bits, 1.25mm (for 1.2mm Copperset pins)	$ 30.00
pk. of 5	drill bits, 1.30mm	$ 30.00
pk. of 5	drill bits, 1.40mm	$ 30.00
pk. of 5	drill bits, 1.50mm	$ 30.00
pk. of 5	drill bits, 1.60mm	$ 30.00
pk. of 5	drill bits, 1.80mm	$ 30.00
pk. of 5	drill bits, 2.00mm	$ 30.00
pk. of 5	drill bits, 2.50mm	$ 30.00
pk. of 5	drill bits, 2.80mm	$ 30.00
pk. of 5	drill bits, 3.175mm (for tooling/registration pins)	$ 30.00
CARBIDE MILLING TOOLS		
each	copper milling cutter, T-Tech style T1, 60°	$ 28.00
each	copper milling cutter, T-Tech style T3, 60°	$ 28.00
each	copper milling cutter, T-Tech style T8, fine-line	$ 28.00
each	copper milling cutter, T-Tech style T4, very fine-line	$ 35.00
each	profile router bit, 1.0mm	$ 15.00
each	profile router bit, 1.6mm	$ 15.00
each	profile router bit, 2.0mm	$ 15.00
each	profile router bit, 3.0mm	$ 15.00
each	end mill, 0.005" (0.127mm)	$ 60.00
each	end mill, 0.008" (0.2mm)	$ 55.00
each	end mill, 0.010" (0.25mm)	$ 50.00
each	end mill, 0.012" (0.3mm)	$ 40.00
each	end mill, 0.015" (0.38mm)	$ 30.00
each	end mill, 0.020" (0.5mm)	$ 30.00
each	end mill, 0.031" (0.8mm)	$ 20.00
each	end mill, 0.040" (1.0mm)	$ 25.00
each	end mill, 0.050" (1.27mm)	$ 20.00
each	end mill, 0.062" (1.6mm)	$ 20.00
each	end mill, 0.125" (3.175mm)	$ 20.00

BOARD MATERIAL, MODEL 7000 (300mm x 450mm / 12" x 18")

pk. of 8	12" x 18" single-sided FR4 material, 1.6mm	$ 128.00
pk. of 8	12" x 18"double-sided FR4 material, 1.6mm	$ 128.00
pk. of 8	300mm x 450mm solder plated single-sided FR4 material, 1.6mm	$ 192.00
pk. of 8	300mm x 450mm solder plated double-sided FR4 material, 1.6mm	$ 192.00
pk. of 8	12" x 18" FR4 material, other thicknesses as available*	$ 152.00
pk. of 8	300mm x 450mm FR4 material, solder plated, other thicknesses as available*	$ 216.00
pk. of 8	12" x 18" foil-clad back up board, 3.2mm	$ 104.00
pk. of 4	12" x 18" foil-clad back up board, 3.2mm, self-adhesive	$ 84.00
pk. of 8	12" x 18" entry foil	$ 48.00
pk. of 8	12" x 18" entry foil, self-adhesive	$ 72.00

BOARD MATERIAL, MODEL 5000 (225mm x 300mm / 9" x 12")

pk. of 8	9" x 12" single-sided FR4 material, 1.6mm	$ 80.00
pk. of 8	9" x 12" double-sided FR4 material, 1.6mm	$ 80.00
pk. of 8	225mm x 300mm solder plated single-sided FR4 material, 1.6mm	$ 120.00
pk. of 8	225mm x 300mm solder plated double-sided FR4 material, 1.6mm	$ 120.00
pk. of 8	9" x 12" foil-clad back up board, 3.2mm	$ 72.00
pk. of 4	9" x 12" foil-clad back up board, 3.2mm, self-adhesive	$ 52.00

* Board material is frequently available in thicknesses from 0.5mm to 3.2mm. If you have a need for material other than standard 1.6mm, please call. Some thicknesses are also available with a rolled solder coating to reduce tarnish and improve solderability.

OTHER ITEMS

each	Allen screwdriver for spindle chuck	$ 12.00
each	toolgrip tweezers	$ 60.00
each	Copperset kit	$ 285.00
pk of 20	Copperset bail-bars, 0.8mm, 1.0mm or 1.2mm	$ 35.00
each	Harwin 0.85mm via pin insertion tool	$ 90.00
pk of 500	Harwin 0.85mm via pins	$ 30.00
pk of 10	dowel pins	$ 40.00
pk of 10	grub screws for drill chuck	$ 10.00
tub	moly grease for leadscrews	$ 12.00
pair	spindle motor brushes (24 volt motors)	$ 40.00
pair	spindle motor brushes (6 volt motors)	$ 20.00
pair	spindle motor brush springs (6 volt motors)	$ 20.00
200ml can	Electrolube clear protective lacquer CPL200H	$ 12.00
100g tub	QuickConnect through-hole conductive paste	$ 400.00
each	replacement pressure foot assembly	$ 85.00
each	radius button for pressure foot	$ 10.00

PRICES ARE IN AUSTRALIAN DOLLARS

PRICES DO NOT INCLUDE SALES TAX OR DELIVERY

A MINIMUM VALUE OF $100 APPLIES TO ALL ORDERS

TERMS ARE NETT 14 DAYS TO APPROVED ACCOUNT CUSTOMERS

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- PLEASE CONFIRM PRICES WHEN ORDERING