

Profiler Update

Experience, tips and helpful hints

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A year and a half after the launch of the Profiler milling machine, it's time for a brief look back on this project. What can this machine do, and what experience have its users acquired with it? We also want to mention a few tips and helpful hints here.



The Profiler project initiated by Elektor in cooperation with Colinbus in January 2007 has proven to be an overwhelming success. At last there was an affordable milling machine available that could handle diverse jobs. Unfortunately, this machine proved to be more difficult to build and use than some of its purchasers expected. This led to a few unhappy users, especially in the early days. However, most users went to work enthusiastically and managed to produce true works of art with their Profiler within almost no time, which they exhibited on websites and in Elektor forums for the whole world to see.

In this article, we want to summarise the experience of the past one and half years and discuss a few important aspects of using milling machines in general and the Profiler in particular.

What did we have in mind?

The Profiler is a robust machine that is suitable for relatively substantial engraving and milling work. However, it has its limitations, just like all other machines on the market. What did people expect and what did they receive, what experience did users have with machine tools, and how much time were they willing to invest in making up for any lack of experience? Many of the early purchasers clearly had

unrealistic expectations about how easy it is to use a milling machine of this sort, and they were thus disappointed with its capabilities or the results.

When we put together the Profiler kit, what we had in mind was the following: the design and construction of the kit must be clear, so that everyone with a bit of technical knowledge could easily assemble the machine. The resulting machine must be sturdy and sufficiently robust for machining light materials, and accurate enough for standard engraving work. In other words, it should be a general-purpose tool for model builders as well as electronic hobbyists.

The kit idea had one major advantage: the price could be reduced drastically. However, it had the immediate disadvantage that the ultimate quality of the product was determined by the builder. Within a few weeks after the launch, it became clear that this was a major factor. For example, quite early on there were a few dissatisfied customers who couldn't manage to put together a properly working Profiler, even after many fruitless telephone conversations and e-mail communications. They were invited to visit the Colinbus factory for personal assistance, and in most cases correct adjustment or better alignment turned out to be the answer to their problems. These users later proved to be the best promoters of the Profiler kit.

The included software

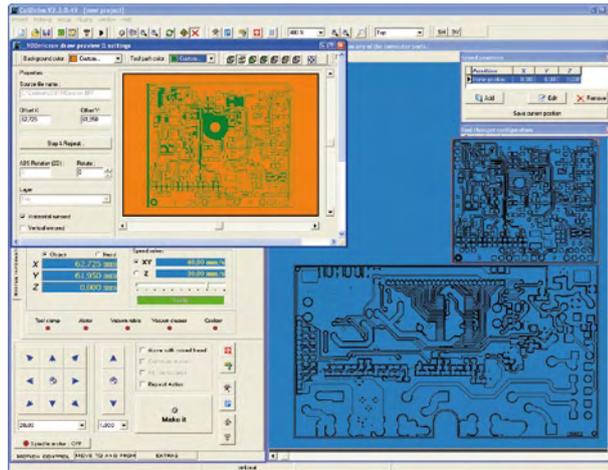
Two software packages are included with the Profiler as standard: ColiDrive [1] and ColiLiner. Both of them are derived from professional programs that have more to offer in terms of options and performance. The supplied versions are so specifically aligned to the needs of typical Profile users that every desirable function is available if the user has a bit of skill. You can import drawings for milling shapes and generate contours for milling prototype circuit boards. This works quite well, as can be seen on many user websites.

However, the customer support department of Colinbus received many questions, especially about the ColiLiner conversion program, which converts Gerber files into contours for the Profiler. The problems here had less to do with the supplied software than with the complexity of the Gerber standard. This format has a vast number of options and variants. Besides using the prescribed apertures, makers of PCB design packages can also use forms they create themselves, and they can work with different units at the same time. Given this situation, producing software that provides the right conversion at the press of button under all conditions is practically impossible. The problem files that Profile users sent to the support department were read in using a variety of Gerber viewers. Where one file might work perfectly with viewers X and Y but not with A and B, another file would work OK with A and B but not with X and Y. However, most of the viewers and ColiLiner had one thing in common: after a few minor adjustments to the settings, the right PCB always appeared on the screen. Unfortunately, adjustments of this sort require a certain amount of knowledge of the Gerber format or suitable patience. Once you have found the right settings for your CAD software, all subsequent files can be imported without any problems.

As the name suggests, ColiDrive is the software that you use to drive the machine. Unlike what some people mistakenly understood, it is not a CAM package with integrated control functions. As with most CNC machines, the idea is that ColiDrive receives machine code from a CAM package (ColiLiner is an example of a CAM package, but as already mentioned it is primarily designed for use in the electronics sector). Incidentally, with many CNC machines the users must write their own code, and this is also possible with ColiDrive.

As the number of delivered Profiler kits increased, it became clear that there was a strong need for direct data import capability. In hindsight, this is not surprising. Up until then, ColiDrive had only been supplied to the professional sector. In this sector, a machine is purchased for a particular purpose, and buying CAM software specifically made for this market is taken for granted. This is not the case with the Profiler. For this reason, a few weeks after the launch we decided to add an HPGL import function. As just about all commercial CAD packages can export in this format, with the inclusion of the import function it became possible to engrave or mill any desired shape without having to use a special CAM package.

Of course, you can do a lot more with real CAM software. A lot professional CAM packages have a postprocessor for ColiDrive. If you do not have this, it is very easy to write one yourself. The ColiDrive data structure is described in the document available at the following link: www.colinbus.com/profiler/commandset.pdf.



1

How to improve your Profiler

The spindle motor

When the Profiler was launched, the primary consideration was to supply a sound machine. To ensure that its owner could use also use it right away, the kit was completed with a simple spindle motor and an MDF base plate. This is a



2

good solution for experimental use or simple milling work. Depending on the objective, you can continue using the machine with this configuration or acquire more professional tools

The spindle motor included with the kit is suitable for milling materials such as balsa wood and relatively soft plastics. If you want to machine harder materials or do more precise work, it is certainly worthwhile to invest in a better motor. The fact that quite a few people were nevertheless satisfied with the performance of the machine was a matter of pure luck, since some of the motors had 0.01 mm of play, while others had 0.5 mm. But as many people remarked on the Elektor forum, the price/performance ratio was reasonable.

If you want something better, you must first ask yourself what sort of work you want to use it for. Do you want to do very nice, fine engraving, do you want a powerful motor for milling hard metals, or do you want both? A truly professional spindle motor is expensive – as much as several times the price of the Profiler. It is thus questionable whether such an investment is sensible.

Practical experience shows that an AC spindle rated at around 500 watts is the most suitable. More powerful motors are generally too large and too heavy for the Profiler.

3



Unlike most DC motors, AC motors of this sort are also affordable. When looking for a motor, remember that it must be designed for machine mounting. You can see this from the steel mounting ring, which is used to attach the motor to the machine, and which also usually houses the bearings. The bearings must be suitable for machining use. Kress has a suitable motor, which is actually a bit too heavy for the Profiler, but the price is attractive. Colinbus can supply the IAC-500, which is ideal in terms of weight and precision, but it is considerably more expensive. A variety of similar products are available under various brand names, and we recommend comparing them and carefully weighing their pros and cons. For Profiler users with deep pockets, there is also the Jäger brand. These motors are very powerful and highly precise, and they are very lightweight. The only problem here is the price.

The base plate

A relatively thin MDF board is supplied with the Profiler for use as the base plate. If you want something more robust, pick up a piece of board at a builder's merchant with a thickness of 20 mm (it hardly costs anything), which will

provide the basis for an inexpensive but stable support surface. If you want to invest a bit more, you can of course buy a plate with slots for T-nuts or a vacuum table. Each of these options has its own specific advantages, depending on what kind of work you want to do.

A vacuum table is ideal for machining flat material and films or for securing material without subjecting it to excessively strong forces. A vacuum table is particularly suitable for jobs with repeat parts. You can simply place the workpiece against a stop on the table, switch on the vacuum, and start machining. With a few accessories, you can also have the vacuum table or dust extraction system switch on automatically.

A T-slot table (see the lead photo) is ideal for clamping relative bulky workpieces. Nuts with a built-in spring can be slid into the slots and used with screws to secure clamps and blocks. The spring nuts can be shifted in the slots, which makes it very easy to clamp workpieces with different dimensions.

Naturally, you can also use the Profiler to make your own T-slot or vacuum table. However, you should bear in mind that making a decent T-slot table is relatively expensive and takes a lot of work. By contrast, making a vacuum table is relatively easy.

Milling 2D, text and PCBs

Beside learning how to operate machine tools, programming in G code and studying the properties of materials, professional milling machinists in training spend a year learning machining techniques. Naturally, the average Profiler user does not have this knowledge.

Thanks to the user-friendly interface of the Profiler and modern CAD/CAM packages, relatively inexperienced users can also produce very nice results with CNC machines. However, this does not mean that there is no longer any need for some knowledge of machining techniques. Although the user can usually have the machine do what he wants, the machine does not always do what it is supposed to do. In fact, it often doesn't. Poor milling results are usually not the fault of the machine or the software, but instead almost always a consequence of incorrect settings. Nevertheless, hundreds of users have shown that splendid results can be obtained with a bit of patience and experimenting. If you do something wrong and the Profiler gets stuck, there's no need to panic. It may complain, but it won't break. The message here is: try to find the best settings for each machining operation.

Milling 2D shapes and engraving text

The Profiler is primarily constructed for milling all sorts of 2D shapes. Many users draw the shapes in ColiLiner, generate the milling paths, and leave the rest of the work to ColiDrive. ColiLiner is not a real drawing package, but can still do quite a lot. For instance, you can use all standard text fonts, and most drawings work out nicely. However, if you want to use your own drawing package, simply export the drawing as an HPGL file and import it directly into ColiDrive.

Milling 3D shapes

The Profiler is not actually designed for 3D work. Nevertheless, it can be used to make very nice 3D shapes. This statement on our part drew a certain amount of criticism from users, and some explanation is in fact necessary. With a real 3D machine, the three axes are interpolated simultaneously. This is not the case with the Profiler. Only two axes can be interpolated at the same time, so the third one al-

ways comes afterward. It is thus possible to mill 3D shapes, but the end result not as nice and it takes much longer. For this reason, many people who like to make 3D forms first mill the shape and then finish the piece by hand (sanding). The final result looks surprisingly good.

Additional CAM software is necessary for 3D milling; it is not included with the Profiler. For example, Colinbus can supply DeskProto as an affordable solution. This package is not especially suitable for 2D milling, but it is a very powerful tool for making 3D models.

Milling PCBs

The Profiler is supplied with ColiLiner Lite (especially for *Elektor* readers who would like to mill the occasional PCB). The software supports reading in a Gerber or Excellon file and then milling channels around tracks and pads. This isn't as easy as it sounds. As far as we know, there are only a few software packages on the global market that can handle this, and they are either very expensive or are only supplied together with expensive milling machines.

The fact that the Profiler is supplied with this software does not really mean that the Profiler is a true PCB milling machine. This was already clearly stated in the first article. However, the many links and photos that users sent us clearly show that it is possible to mill good PCBs with this machine. As we have received a lot of questions on this subject, we want to address it here in somewhat more detail. Milling PCBs is becoming increasingly popular. This is not because it is better than etching, but instead because it is faster and more environmentally friendly for one-off boards. With a true PCB milling machine, you can easily mill five tracks between the pins of an IC, which is more than good enough for modern circuitry. If you want to get acceptable results with the Profiler, it's only logical to have a look at how the pros do it: what tools do they use, and how do they achieve such amazing results?

Fitting the PCB is an important factor. The best way to do this is to use two small pins, since this way you can also make double-sided boards (even with the Profiler). ColiDrive is certainly not an obstacle here, since it is specifically made for this and shows an imaginary mirror line on the screen.

In practice, you start by drilling a hole with a diameter of 2.95 mm, located approximately in the middle of the X axis and at the start of the Y axis. Press the first reference pin in this hole [4]. Use a 3-mm dowel pin and ensure that it protrudes by approximately 4 mm. Now drive the machine bridge straight backward and drill a second hole approximately 20 cm away from the first one. Press the second reference pin in this hole. Store the location data in ColiDrive so the software knows the position of the reference line.

If you use a T-slot table, you can drill the holes in small plastic blocks. You can then use all different sizes of PCB material by sliding these blocks to different positions. To avoid any misunderstanding, note that the idea here is to mount PCB material on the machine and then mill one or more PCBs in the material.

As you also have to drill holes in the PCB, you have to use underlay material. Use a small board with a thickness of 2 mm for this – preferably a material that stays nice and flat, such as MDF. In this material, drill two 3-mm holes with exactly the same spacing as the on the reference board, and then place it over the two reference pins. Do the same thing with the PCB material. **Note:** single-sided PCB material may be slightly bowed, and if it is, it must be held flat with clamps or tape.

Now you have the material on the machine, and you can start making the PCB. Drill the holes first, as otherwise thin

drills may break or thick drills may chew up the pads. There's not much that can go wrong during this process, since ColiDrive always asks you to fit the right drill in the holder. After all the holes are drilled, you can use small conical milling cutters to the tracks. End mills are too fragile for this work because the insulating channels are very thin, and they also wear much too quickly. To ensure that no residual copper is left, it is necessary to mill a little way into the tough epoxy material, and this dramatically reduces the life of the cutters.

Using conical cutters also has some disadvantages. In particular, the milling depth must be controlled precisely, as otherwise the width of the milled channel will vary, which creates problems with fine circuit board tracks. Most Profiler users solve this problem by first milling the base plate perfectly flat. If the PCB material is then fastened securely and held flat, the milling depth remains constant.

A better alternative is to use a floating cutter head. With this arrangement, the spindle motor is mounted in a holder that can move freely along the Z axis. The bottom ring slides over the surface of the PCB and ensures that the cutter – which is always at a fixed distance from the ring – maintains a constant cutting depth in the copper. If you use this arrangement, it doesn't matter whether the material is flat



or bowed (within certain limits, of course) – the milled channels will always have a constant width. As floating cutter heads are usually adapted to the spindle motor that is used, they are difficult to find as commercial products. However, it's fairly easy to make one yourself once you understand the principle.

After the PCB has been completed, it can be milled out of the base material. This is usually done with a 2-mm roughing cutter. Do this at a very low feed rate, such as 5 mm/s, since otherwise too much heat will be generated and the tool will break.

A manual for using the Profiler to make PCBs is available on the Colinbus website at www.colinbus.com. For instance, it describes how you can make double-sided PCBs, despite the limitations of ColiLiner Lite. Be sure to download it – it's certainly worthwhile.

Handy milling tips

If you read milling tips on the Web or consult professional literature, you often obtain information about using large milling machines to machine materials. The Profiler is not

a large milling machine, and it must be used in a different manner.

In the first place, you use smaller tools with the Profiler. Unless you are working with very soft material, a 6-mm cutter is already quite large. Given that you are working with relatively small tools, it is often advisable to use a fairly high feed rate (the rate of travel for milling) and restrict the cutting depth. It is thus better to mill somewhat faster but not too deep. If you follow the suggestions listed below, your milling work will look a lot better.

How to mill: As we just mentioned, keep the cutting depth fairly shallow – the quality degrades quickly with increasing depth. Mill clockwise on inside curves and anti-clockwise on outside curves. This yields the best appearance on the final product.

Which cutters: Cutters are available with one, two, three, or four flutes. This refers to the number of cutting edges around the circumference of the cutter. Each type has its own properties. Single- and double-flute cutters are used for most jobs with the Profiler. Triple- and quad-flute cutters



5

are primarily used for hard alloys, and the Profiler is not suitable for these materials.

Single-flute cutters are primarily used with wood and plastics, but nowadays they are also used with aluminium, due to the use of stronger cutter materials. Single-flute cutters enter the material better and have better chip removal than double-flute cutters.

Double-flute cutters are the best choice for milling plastics and non-ferrous metals. They produce a smoother finish and wear less quickly. They are also often used for a final polishing round.

Cooling: Cooling is almost always necessary [5]. The type of cooling depends on the material to be machined. As it is not possible to use liquid-stream cooling with the Profiler, the following tips can be helpful.

Copper, bronze, brass and aluminium can be cooled quite well with methylated spirits. Thin oil is also good for cooling aluminium. You can use a small brush or plant sprayer to apply the liquid. A couple of handy youngsters remodelled a paintbrush and fitted it to the machine.

Spindle speed: With plastics, the result is strongly dependent on the feed rate and spindle speed. A high spindle

speed can be used for milling metals, but this is often inadvisable with plastics. With a high spindle speed, the plastic melts and sticks to the tool, and everything gets stuck.

Although many people may not believe it, the feed rate is often too low. A lot of heat is generated if the cutter moves slowly through the material, and this causes problems. If nothing else works, try cooling with compressed air.

Solid-core board (such as Trespa) can be milled very nicely, but it causes a high rate of tool wear. Always enter the material very slowly, because the highest rate of cutter wear occurs during plunge cutting.

Always use single-flute cutters for milling polystyrene and foams. Cooling is rarely a problem with the correct machining speeds. If cooling is necessary, you can only use air.

Securing the tool and workpiece: Always insert the tool as far as possible into the holder. Tools that extend a long way create troublesome vibrations. The work table must be flat and stable. The T-slot table (optional accessory) is very suitable for this purpose. The workpiece must be held firmly so no vibrations can occur and it cannot slip (which is much worse). Use clamps to secure the workpiece firmly in place. Spray-on glue and double-sided tape are good options for thin or light materials.

Applications

Many enthusiastic users have sent photos, drawings, and stories about the various applications they have found for the Profiler. Many of them came from departments of large companies that use the Profiler as a platform for experiments, but they also came from many hobbyists and self-employed persons. Some examples:

- A large cosmetics company used two Profilers to fill more than 800,000 bottles.
- Several users drill hundreds of PCBs every day with the machines.
- A builder of architectural models created a model of an entire neighbourhood in a month.
- A user in the diamond business uses three Profilers to measure and check diamonds.
- A lot of users employ the Profiler for potting and dispensing...
- ...or for ultrasonic cutting of plastics.
- A toy manufacturer uses it to produce all of its new models.
- And of course, there are hundreds of hobbyists who make incredibly nice things, such as lifelike cockpits (hi Hessel), miniature cars, microscopic components, splendid jewellery, clocks, and very fine printed circuit boards.

As you can see, everything is possible with this milling machine if you just put some time and effort into it. Check the Profiler forum on the Elektor website for even more ideas, tips and reports on user experience.

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The Profiler kit can still be ordered on the Elektor website. Colinbus presently has around 100 kits in stock in the warehouse. If you order now, the kit can thus be delivered quickly (as long as stocks last).