

The story of the Microline

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“Microline” is the brand name of OKIDATA’s Serial Impact Dot Matrix (SIDM) printers, which are currently used all around the world. Here, we look at the birth of the Microline, its subsequent development and future prospects, plotting the technological developments which lie behind the world-wide success of this brand.

The birth of the Microline

In September 1978, Oki signed a deal to supply low-cost printers to the U.S. firm Tandy / Radio Shack. These printers were designed to be used as output devices connected to personal computers, which were only just coming onto the market at that time. In response to the deal, our Technical Department embarked at full speed on the design and trial manufacture of a compact printer. The engineers finally finished their job and completed the new printer, just at that year’s traditional New Year’s Eve song contest was starting on the television. Early in the new year, the head of the Technical Department set off to the USA with the new compact printer packed inside a special case. This printer, the ML (Microline) 80, was the very first Microline model and had a 7-pin wire dot head based on an SIDM system, making it much smaller and lighter than previous printers.¹⁾

The ML80 had a very simple overall structure, as detailed below.

- (1) Mechatronic section
 - Print head 1
 - Pulse motor 2 (main scan and sub scan)
- (2) Control section : 1 x single-side circuit board (size : A5, including power supply section, except for transformer)

Prior to this model, our main line of printers had been type printers, using cylinder or petal type heads. These devices had excellent performance compared to other typing printers of the time, but were at least as heavy as a current A3 colour printer.

The ML80 went on sale in 1979, and its engine was also mounted in the PC if800 model 120, a model of Oki-brand PCs. This model progressed into the consumer goods market and generated some turnover, although never to an extent that hinted at the “Old Microline” and “New Microline” printers that would follow later.

With production runs of hundreds and thousands of machines, the ML80 represented a much bigger product than the models that had gone before. Any design errors would cause huge problems in the factory, and in such cases, the Production Department would direct sharp criticism at the Technical Department. However, three years down the road, by the launch of the next model, now called the “Old Microline”, the Production Department had come to work in much closer harmony with the Technical Department.

One unique memory of the early Microline is the way we dealt with FCC (radiation noise standard) measures. At the time, we did not have access to an EMC shielded room or open site, like we do today. So we decided to measure the device in the dining hall, which had a large enough space to imitate an official site. We moved all the dining tables to the sides of the room, took our measurements, and then had to move everything back as lunchtime approached. After lunch, we had to set it all up again – it was a lot of work! Looking back on it now, it seems amazing that, using a measurement environment like that, we never once failed an official site test.

The success of the Old Microline

1981 saw the launch of the ML82A (A4) and ML83A (A3) printers, which would later come to be known as “Old Microline”. These printers had a really solid build,



Photograph 1 Old Microline ML92
(Gold plated to commemorate one million printers manufactured)

and were called “tank-tough”. The age of mass PC production and sales was dawning, and rivals, both at home and overseas, were starting to market compact SIDM printers for use with personal computers. Our U.S. sales company, OKIDATA, rode this trend and started to ship the Old Microline in large numbers. We began to manufacture and sell printers on a scale we had never experienced before.

In technical terms, the Old Microline was a great step forward. This advance was based on the high-reliability impact heads developed by Oki. These heads used a spring charging system, wherein a pin (wire) welded to the end of a spring was lifted up by magnetic force, and the pin was then struck against the ink ribbon by the force of the spring. Our spring charging system had many benefits over the clapper systems (which strike the pin by magnetic force) used by other firms, in terms of faster speeds, higher printing force, and mass manufacturability.

However, the springs and pins in the spring charging system were liable to breaking, and required daily screening at the head plant. In some cases, a whole production lot would have to be discarded. To improve head reliability and welding reliability in particular, we introduced YAG laser welding machines, still a novelty at that time, into our mass production line. We also devised and implemented a wire rotation test device to inspect pin breakage. This test device applied a stress to the whole wire by bending and holding the wire and then rotating it, so it provided very reliable results. Another special point of interest is the ultra-hard wire we developed for the pins. This increased costs, but eliminated pin breakage and ensured durability. The ultra-hard wire made it possible to achieve strong printing force at the same time as high-speed printing. We were also able to use the optimum black pigment, carbon black, in the ink ribbon. Other companies’ heads used tool steel for the wire, which produced severe friction if used with carbon black ink ribbons, and therefore had to settle for ink ribbons with less durable dye. Our high-reliability printhead really boosted the Microline’s reputation, and created the user’s belief in a “printer that never breaks down”.

Nevertheless, the spring charging system, with its high electric power requirement, was to prove obsolete 2 – 3 years down the line, with the introduction of budget 24-pin printers aimed at domestic word processor users. In later years, the market would switch again, this time to ink jet printers. Still, our incorporation of spring charging and ultra-hard wire into wire dot heads was the foundation for Oki’s strong and lasting presence in the SIDM printer market.

Behind the high reliability of our printers lay Oki’s technical traditions as a manufacturer and supplier of products for NTT and financial organizations over many years. These traditions helped us to build printers that, in addition to having excellent print

heads, would never jam or malfunction. Moreover, by looking at rival printers, we realized that they had been able to cut costs by learning from our developments, but rather than resting on our laurels, we continued to build our company’s success by maintaining the highest standards of reliability in the technology we used.

The New Microline and the advent of the robot assembly line

In 1984, we launched the ML182/192 and ML183/193 printers²⁾, known as New Microline (Photograph 2). The New Microline incorporated further size and weight reductions, and its compact shape made it easy to locate anywhere. New technical innovations included a self-running head carriage and a re-inking system, technology which is still used in the current Microline models. In addition, the number of components was cut to approximately one-half the number in the Old Microline. A new direct drive motor for the self-running head carriage and a new sub scanning motor were developed and produced in-house.

Production engineers were included from the very first design stages of the New Microline, to achieve a design compatible with mass-production assembly by robots. One result of this was our adoption of a cable-less installation system, which required development of custom connectors in place of conventional ones. These are still used in parts of the current 300 series. To achieve cable-less installation, a pressure-contacting system was adopted for coupling the respective units. This gave rise to vibration-related problems, which were very difficult to overcome, but the technical solutions we eventually devised also provided an excellent knowledge base for future developments.

The control section was the first at the time to use a custom LSI (made by Oki). In order to reduce the size further, we used surface mount technology for the first time, and this helped to increase mount density. Another new feature was our adoption of an integrated driver for the head and motor drivers.

In the direct drive for the self-running head carriage in the main scanning direction, we



Photograph 2 New Microline ML182

introduced a new brushless motor, developed in-house by Oki, which was controlled by a digital servo drive system. Although digital servo drives had been used in some products before this, they entailed both advantages and disadvantages, due to the large number of components in the digital control section. However, with the development of our custom LSI, we were able to establish an excellent control system which avoided massive expansion of the logic control section. Moreover, by using the same pulse motor as previous models for sub scanning, and developing a single-chip motor driver in conjunction with other manufacturers for the control method, we were able to adopt a new bipolar drive system. This control system was widely adopted in subsequent SIDM printers.

Two robotized assembly lines were set up to manufacture the New Microline printers : one in Fukushima (for export) and one in Takasaki (for the domestic market).

The 300 series

In 1987, Oki started shipment of the ML320/ML321 and ML390/ML391 printers (Photograph 3). This “300 series” was solidly built and designed to provide high-speed and high-quality printing. Although the technology had already been developed in the 100 series, the 300 series printers were still brought to market in a very short timeframe. The ML320/ML321 were 9-pin head budget models, whilst the ML390/ML391 had 24-pin heads for high print quality. The 300 series revived the “tank-tough” image and increased our printer sales. OKIDATA had initially forecast that the 24-dot printers would outsell the 9-dot versions, but in fact, the 9-pin ML320/ML321 was our best seller. The 24-pin printers took more time to establish themselves, but were highly valued in the VAR (Value Added Reseller) market and also sold well.

One of the technical features of the 300 series was the completion of the “full moulding” system. This meant that the lower cover and the chassis could be formed by a single, unified moulding, rather than having to use metal plates for the bodywork. At the same time, the number of screws required to secure the moulded components when fitted together was reduced to just six, in other words, a practically screw-less structure was achieved.

The paper handling mechanism was also improved. Two paper feed paths were provided : a push tractor forming the standard paper supply, and an optionally selectable pull tractor like that in previous models.

The full moulding case structure used in the 300 series, and the vertical mounting of the control PCB, really made it hard to pass FCC regulation. Seeing as the 9-pin and 24-pin models were being developed simultaneously, at first, we worked on them jointly in the shielded room. However, in the end, this was not



Photograph 3 Microline 320

big enough and we had to set up another measuring device in the gymnasium. By working round-the-clock, we just managed to meet the testing schedule.

The 100 series was aimed at the low-end market, and the 300 series, at the VAR and middle end markets. We had also brought out a high-speed printer, called the “Pacemark” for the high-end market. The customers’ faith in the “unbreakable” quality of the Microline meant that we could sell a machine of equivalent specifications to competitors’ products, at a higher price on the street.

We sold many Microline emulations (command modes) of other printer models. In creating these emulations, our firmware development section had to fully research other firms’ products to guarantee compatibility, even to the extent of emulating their bugs. More than a few times, we received complaints that our machines were not working exactly like the other printers, since they functioned normally in cases where the emulated printer had a bug.

Before these printers, we had also developed the ML200 series of 18-pin colour printers. Our choice of 18 pins, rather than 24, was based on our priority of ensuring emulation compatibility. Using 24-dot heads would have prevented compatibility with existing 9-pin printers (ML82A, etc.), whereas 18 was a prime factor of 9, so an 18-dot head would make it easy to guarantee this compatibility. In the end, this proved to be a wrong decision, as the 24-pin models subsequently unveiled by our rivals became the norm in the high-resolution printer market. These 24-pin printers with their emphasis on print quality eventually gained the support of consumers. The key lesson we learnt from this is that, whilst compatibility and other such factors, are of course significant, the most important thing of all is to build a product that the customer really sees as a good product.

Table 1 Microline models and launch dates

	Overseas						Japan and China (kanji printers)					Others	
	9-pin printers		24-pin printers		High-speed (A3)		24-pin printers		24-pin horizontal		High-speed (A3)		
	A4	A3	A4	A3	9 pin	24 pin	A4	A3	A4	A3	24 pin		
1979 (S54)	ML80												if800-model-10
1980 (S55)	ML82	ML83									ET8530		
1981 (S56)	ML82A	ML83A						ET5300	ET8300				if800-model-20
1982 (S57)	ML92	ML93				PM2410							
1984 (S59)	ML182/192	ML183/193						ET5320		ET5320S	ET8550S	ET8550	Oki-Mate ML292/3/4
1987 (S62)	ML320	ML321	ML390 ML380	ML391		ML393	ET5330					ET8560	if800-model-30
1989 (H1)						ML395					ET8560S		
1990 (H2)										ET5320SII			
1991 (H3)						PM3140							
1992 (H4)	ML520	ML521	ML590	ML591			ET5350	ET8350					
1993 (H5)	ML320VE	ML321VE									ET8370S	ET8570	
1994 (H6)			Pass-Book							ET5330S	ET8350S		
1995 (H7)	ML320R	ML321R	ML390R	ML391R									

The 500 series

The 500 series (ML520/ML521, ML590/ML591) fitted with intelligent printheads completed development and went on sale in 1992 (Photograph 4). This series was designed to improve media compatibility and print stably onto different types of print media. The intelligent head technology made it possible to control the printing force in accordance with the undulating surface of the print medium, by detecting the movement of the wires by the change in the electrostatic capacitance, and feeding this information back to the wire driver. By using an intelligent head, the thickness of the print medium and any gaps in the medium can be detected and uniform printing can be achieved.

The 500 series also involved further improvements of the paper feed system used in the 300 series, with



Photograph 4 Microline 520

a three-way paper feed paths compatible with continuous paper and cut paper.

The 300R series

Oki started to ship the 300R series (ML320R/ML321R, and ML390R/ML391R) in 1995. The 300R series was designed as a faster and cheaper (VE) successor to the 300 series. Overseas production expanded, with 300R printers being manufactured at our plants in the UK and Thailand.

The market for laser printers and inkjet printers subsequently expanded and general users moved away from SIDM printers. Nevertheless, customers looking for high reliability and VAR continued to use SIDM models in similar numbers, which meant that we could maintain our Microline sales relatively unaffected.

It seems incredible, but at that time, 9-pin printers were selling for higher prices than 24-pin printers. Our overseas marketing departments told us: "Keep on making 9-pin printers in the same way, without any changes. Only, in the rare case that a rival brings out a new model, raise the speed to match theirs." However, in order to increase our company profits further, we developed the 300R. For general business use, 9-pin printers were sufficient and 24-pin printers involved costs similar to an inkjet printer. However, the 24-pin printers did sell in Japan and China where kanji characters are used. In particular, we were the first company to produce a flat-bed printer, which recorded excellent sales, especially in China. In Europe and North America, the 24-pin printers were not such a big hit as the 9-pin printers, but they have still been excellent, long-lived products which have made their contribution to Oki's business.

If you travel abroad, you will see an Oki Microline somewhere, printing receipts in the hotel or duty-free

shop, installed in a supermarket office, or perhaps, drawing out a location map for a car rental company.

Table 1 lists the names of the different Microline products and their respective launch dates.

The history of wire dot heads

The history of the Microline can be seen as the history of the wire dot head. In 1978, the printer market was dominated completely by typing printers, but as other firms launched its cheap, compact and light-weight SIDM printers, the SIDM market rapidly began to expand. Although we had developed and sold SIDM printers before, the wire dot heads of the time were bulky and heavy, and the printers were big enough to require mounting on special table. In order to make small, light printers at low cost, we started on development of a new printhead in September 1978. Our aim was unshakeable: we weren't going to stop until we had built a compact, light-weight head!

At the time, two different systems were used for wire dot heads: a clapper system where the wires are projected by the end of a movable member, using an electromagnet; and a spring charging system where springs are released by using an electromagnet to cancel out the attraction of a permanent magnet, thereby projecting the wires on the end of springs. We decided to avoid the clapper system, because of our



Photograph 5 Compact wire dot head

rivals' head-start in this technology, and also because it is disadvantageous for printing speed. At that time, spring charging systems were used for wire dot heads in high-speed printers, but they were large and complicated, and also expensive. However, we decided to adopt this spring charging method, and looked for possible ways to reduce size, weight and cost, and raise printing speed and force, by adapting the central impact principles used.³⁾

Methods for achieving reductions in size, weight and cost included reducing the number of components, cutting the number of fabrication steps, and simplifying the assembly process, and by studying all of these possibilities minutely, we adopted a wire dot head with members layered on ring-shaped magnets (Photograph 5). A simple structure was adopted for the actuator parts, which were formed in a seven-leaved tongue shape pointing in centrally on

a single disc-shaped spring, a dot wire being installed on the end of each actuator. For the dot wires, we tried out practically everything we could think of, including stainless steel, Tufftride-processed stainless steel, tungsten steel, piano wire, and so on, and we eventually settled on the ultra-hard wire we use today.

At first, in the spring charged head, we connected the cylinder-shaped armature to the attract/release part of the plate spring, and soldered the dot wire to the end of the spring, but this did not give sufficient printing force. Therefore, we extended the armature to the end of the spring and connected the dot wire to the end of the armature. This generated adequate printing force, but created a big problem. The armature and plate spring were connected by laser welding, but breaking of the plate spring started to occur at the weld section. Laser welding changes the metallic composition at the weld, and thinking that this might be the principal reason for the problem, we tried welding at various different weld energies, but this did not improve the spring fractures. We then wondered if the problem arose because the weld surface area was concentrated at one point, but even when the number of weld points was increased from one to several tens of points, the springs still broke. We tried other adjustments, but the springs kept on fracturing. Mass production had already got underway, and the reliability of the welds was determined by lot assessment. However, we only hit on a fundamental solution to the problem when one of our production

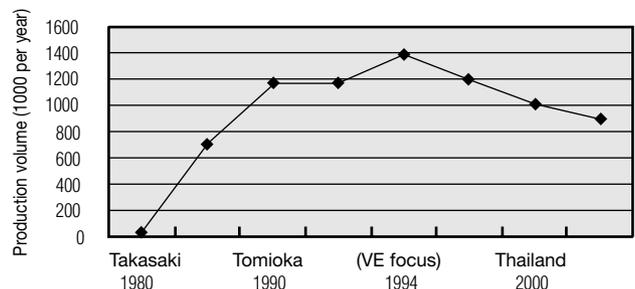


Fig. 1 History of Microline head (9-pin) production volume

technology supervisors commented, whilst clearing away a large batch of defective springs, "What about putting a hole by the weld?" When provided with a hole like this, none of the products broke and reliability testing was successfully completed. The reason for the spring fractures was not the shearing stress and tensile stress acting on the weld, but the peeling force. These days, problems of this kind can easily be analyzed by computer and resolved straight away.

With this problem out of the way, the Microline printer was changed from a 7-pin head to a 9-pin head, and went on to record excellent sales. The high reliability of the wire dot head contributed greatly to the sales of the Microline.

The graph in Fig. 1 traces the production figures for our wire dot head (9-pin) up to the present day. At the start, it was manufactured at our Takasaki factory, and was transferred subsequently to Tomioka, then Fukushima, and is now mass produced at our plant in Chiang Mai, Thailand.

The future prospects of the Microline

The Microline series has won the affection of a huge number of users all around the globe and continues to be used widely, as evidenced by the fact that the ML320/321 (9-pin) and ET-5320 (24-pin), both developed well over 10 years ago, are still selling well today. Brand awareness of the Microline is especially high in overseas markets.

The SIDM market has tended to shrink, year on year – much of this demand has shifted to non-impact page printers, and SIDM technology is having to compete in an increasingly hostile environment. Be that as it may, viewed from a worldwide perspective, Microline products still have an important presence, and still hold a large market share in North America, for example.

Looking at each product separately, we can see that Oki printers in the mid-range upwards have top-ranking market share in every country, confirming the high quality and high reliability that sustains those products. One particular sign of this high reliability is the frequency with which our dealers said to us: “The MTBF (Mean Time Between Failures) stated in the catalogue is lower than the actual figure – why don’t you put it up a bit?”. This image of the “tank tough” printer was not just based on its external appearance, but also reflected its excellent build quality.

The growth period of SIDM printers was based on development concepts stressing performance and high-speed operation, as well as scaling merits. However, now that the market is shifting towards non-impact page printers, and colour printers, new demands for network connectivity, high-performance in terms of total processing capacity, rather than just printing speed, and easy medium setup systems, are emerging. Moreover, in some regions, good cost performance, including running costs and consumables, is an especially important consideration. This requires products suited to different businesses and different regions, rather than the performance-focused product approach which has predominated until now, and it is vital that we clarify the kind of performance specifications we can supply respectively to North America, Europe and Asia & Japan.

The tightening of the SIDM market is undeniable, but viewed another way, this can be seen as a contraction of the market to areas where SIDM printers, with their particular merits, are the only suitable option. From this viewpoint, the target market is becoming ever more clearly defined, and although this solid market

remains, it is essential that we devise our product development suitably in response to this situation.

To achieve this, as well as carrying over the technology used in the Microline series to date and making generic printers based on our high-reliability heads, in particular, we also need to develop flat-bed printer products and fine tune our line-up by product localization.

Whilst global demand for SIDM printers is shrinking, the market looks set to remain extremely attractive in China, and although we have already introduced products into this market, from here on, China will have to be taken increasingly into consideration in developing products. Papers of many different qualities are used in China, so enhanced media compatibility will be required.

Recently, particular attention has been given to tackling global environmental protection, and we have sought to reduce waste products by, for example, adopting re-inking systems for compact, short-length ribbons.

Conclusion

This article has traced the technical story of the Microline, our world-renowned SIDM printer brand, from its birth to future prospects. This is just a part of the story, and does not recount all the other hard work that has gone into creating the Microline. We would of course like to express our deepest thanks to the many people who have supported the Microline project up to the current day, on both the manufacturing and marketing sides, and whom we have not been able to mention in this essay.

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