

The Development of the Emulator II

Based on an Interview with Dave Rossum
on 6th July 2000 – Many Thanks Dave !

A New Team

To develop a ground breaking sampler like the Emulator II, E-mu Systems broke with tradition and assembled a large hardware and software design team of five people (Dave Rossum, Tom Moxon, Dana Massie, Donna Murray and Alan Goldwater). This was the first time E-mu Systems had created a design team bigger than one person - it had always been Dave Rossum on his own! E-mu Systems knew they had a market opportunity for developing a powerful sampler with greatly improved sample quality, and analog synthesizer features. The Emulator I had sold well (50 units a month) once the basic design had been improved with envelopes and a sequencer. They also knew that there was a lot of work to be done to develop the radically new electronics for the Emulator II. If they left it too long, the Japanese would catch up and enter the sampler market, as they could muster much larger development teams and at a lower cost. It turned out that it would be another 2 years before the Japanese launched primitive samplers. The competition came from inside the USA. Ray Kurzweil began working with Stevie Wonder in 1982 on a new instrument for replaying acoustic sounds (the K250 sampler) – this new instrument first appeared as an engineering prototype in June 1983.

The initial development in fall 1983 started with Tom Moxon and Dave Rossum focusing on the basic design of the new sample replay electronics. Tom had recently joined E-mu Systems - he had previously been a graphics expert in the emerging computer graphics industry. Tom wrote the micro-code for the Emulator II's Microcontroller, which replays the samples from memory. This simple program understands the entire sample looping requirements of every voice of the EII (start, end, forward, backwards). It was a critical improvement in sampler design.

The design took another major step forward when Donna Murray joined the team (Donna now runs his own startup company called Flux Networks). He knew a lot about the emerging area of Digital Signal Processing (DSP) electronics, and he worked with Dave on the design. Whilst dedicated DSP chips were still too expensive to consider using in the Emulator II, some of the techniques could be utilized within the extensive TTL electronics used in the Emulator II. Dave also used two Z80's (up from one in the Emulator I) with a fast parallel interface between them.

The Emulator II implemented three new sampler innovations.

Innovation 1 – Sample Replay

The development of the Emulator II grew out of the work done on the Drumulator, which used a memory register file to control sample replay. This worked well for sounds that did not need any pitch control (e.g. drums), but it was not going to be a good means of replaying samples at pitches different to the original. The Emulator I also suffered from sound quality deterioration, when playing samples back at different pitches. The basic

register file concept was expanded into the Emulator II's "Microcontroller" to enable variable speed replay of the sample to create different pitches. Dave subsequently went on to develop much better sample pitch shirting techniques (as custom silicon chips became chip to produce). These techniques were implemented in the G and G2 chips – and used in the Emulator III and then the Emulator 4/Ultra range.

Innovation 2 – Sampling Quality

The EII was designed differently to the EI and Drumulator which both have companding digital to analog converters. The EII uses analog differential compounding (this coding algorithm couldn't be done fast enough using digital electronics at the time). This made a substantial improvement in the sound quality, especially when compared with the 8-bit Emulator I. This algorithm stores the difference between the samples in a compounding format within the sample memory. This gives the Emulator II an effective sample resolution of 14/15 bits, which is one of the reasons it still sounds good today. When the differences in sample amplitude are small (e.g. at low frequencies) there is a smaller amount of data to be held. This sample coding algorithm works very well for low frequencies, and as most sounds have a low frequency component it work out okay for the Emulator II's entire keyboard range. This innovation meant that the EII delivered a better sound than the paper specification. The over achievement of the design objectives was just the sort of thing Dave expected in E-mu Systems.

Innovation 3 – Analog Filters

Jim Cooper had added a custom modification to the Emulator I, which added analog VCA's and VCF's . This used Dave's original SSM chips (as used in the early Prophet 5's), they were controlled by a new set of rotary controls on the top of the Emulator I's industrial strength metal casing. This was called the Gen Mod. Customers quickly fed back to E-mu Systems how great these analog filters sounded (we can believe this!). Dave was in no doubt that analog filters would need to be part of the Emulator II design specification.

Development Problems

With all this innovation in electronics, the design was beginning to become seriously behind schedule by the late fall of 1983. Dave had to pull out of a five week vacation to Nepal (to climb a 20,000' mountain) in order to keep the project going. He ended up with a two week holiday in Ecuador over Xmas 1983 instead. The prototype made it to the 1984 NAMM show in January as a pre-production prototype. However it really was pre-production! The EII electronics were still on wire wrap boards in a card cage, and not in the EII housing. So they were hidden under the table with covers, and connected to the functioning EII housing and keyboard on top of the table via a ribbon cable. No one let on, and no one found out. Dave had convinced people that the Emulator II was a production machine. It generated a high degree of interest at the NAMM show.

Well it wasn't finished ... and it took another 6 months to get the EII into production! The EII development project continued into Spring 1984 still running late. The EII needed a stronger power supply, and at the June 1984 consumer show the demonstration machines had some embarrassing power failures.

By the spring of 1984 the EII development was not only late, but creating major cash flow problems for E-mu Systems. Marketing had decided to discontinue production of the reasonably popular Emulator I in the fall of 1983, in the anticipation of the EII being available from early 1984. But the EII was far from being ready, and the rest of the product line was also in trouble. Drumulator sales, which had been so strong in 1983, were falling off due to the flash new Oberheim DX drum machine, which had better features and newer technology.

The only other product was the troubled E-drum, which had been rushed out in early 1984 and promptly hit design and customer problems. In fact the E-drum turned out to be a catastrophic failure for E-mu Systems, it doesn't even appear in their web page time line of products! E-mu Systems was in crisis, and in spring 1984 there were major layoffs with 50% of staff going. Some came back once the EII took off later in 1984, but some were disgruntled after putting in so much hard work to transform the company from producing analog modular synthesizers to cutting edge digital samplers.

Well the EII did make it into production in June 1984, and all the effort and delays paid off. It was a miracle product for Emu Systems, a massive hit with musicians and with the memory and HD upgrades it became a long lived and well rounded sampler. Around 2000 were manufactured.

No real competition

When the EII was shown in January 1984, the Kurzweil K250 was still in prototype form with great sounding piano samples and a 16-bit 4MB RAM specification. Initially this looked like strong competition, but it was still very obviously a prototype (no hidden card cages here!), and E-mu System knew they were further ahead in product development. It turns out that the two instruments are similar in terms of sample quality. By July 1984 it was clear that the Kurzweil was aimed at reproducing high quality Grand Piano sounds (thanks to the involvement of Stevie Wonder in the project – he wanted acoustic samples), and that this was a different market to the “synthesizer/sampler” target that the Emulator II was designed for. Some months later Dave and the team acquired a Kurzweil and looked inside. They were expecting it to be DSP based but it turned out to be based on a similar architecture to the EII. The sample pitch was altered by changing the sample rate.

Scott goes to Congress

The EII Hard Disk model was a challenging project in itself. The engineering needed careful work to ensure the EII power supply was strong enough for the extra power required, and that the heat generated did not cause problems. The prospect of using a delicate and very expensive hard disk in a portable musical instrument was daunting at first, and a substantial shock mount was used. In reality the drives proved reasonably reliable, and E-mu Systems concerns of failure did not materialize. The drives were manufactured in Singapore, and imported into the US. They required an export license to be shipped out of the US, to the European market. So Scott had to testify to Congress to enable an export license to be granted!