More About Envelopes

Synth Secrets

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Gordon Reid reveals some of the limitations of the 'classic' ADSR envelope with reference to a practical synthesis example, and explains some of the different types of envelopes found on 'classic' analogue synths, from AR envelopes right up to highly flexible digitally controlled EGs.

I mentioned at the end of the last Part of this series (SOS November 1999) that people often start collecting synths when they begin to appreciate that some are better suited to certain tasks than others. As your understanding of synths grows, so too can your collection. So, imagine now that you're standing in the midst of just such a carefully assembled collection of analogue classics. What would you find there? Undoubtedly plenty of Sequential gear; a Prophet 5, say a couple of Prophet 10s, a Prophet 600 and a Prophet T8. And Rolands, of course; there'd probably be several A-frame stands sagging under the weight of Jupiter 8s and 6s, and JXs of all descriptions. You'd have to have something from Oberheim's heyday in there too, like an OB8, and maybe a Memorymoog to represent the work of Dr Robert's pioneering company. Then there'd be a few oddities, like rare analogue Kawais and a Crumar Spirit. No need to stop at keyboards, either. You'd have to include various Roland MKS-series rack synths, like the MKS30, -70, and -80, plus maybe Crumar Bits and Cheetah MS6s.

What a selection! Surely, with classics like these, there's not a sound in heaven or on earth that is beyond your synthesis capabilities? Well, actually, the ugly truth is that there are *plenty* of very common sounds these so-called synthesizers can't, um, synthesize — and one of the major reasons for this has to do with their contour generators (or envelope or transient generators, as you may prefer to call them). You see, every one of the analogue synths in the list above (and most others besides) uses the ADSR contour generators we discussed in Part 3 and Part 7 of this series. And, flexible as these are, there are many, many sounds that you can't imitate using 4-stage envelopes. But don't just take my word for it; let's consider what's necessary to synthesize a fairly common-or-garden sound and you'll soon see what I mean.

Bold & Brassy

Imagine you're trying to synthesize a realistic spit brass sound that goes 'psst' at the start and then swells to its full glory. Just by using our ears, we know that sounds such as these start out from silence, and exhibit a pronounced 'spit' at the start of the note. They then drop back to a significantly lower level and more muted timbre before swelling slowly to their full volume and brightness. Finally, notes decay quickly to silence once the players stop blowing. The volume and brightness contours of any such sounds will therefore look something like the curves shown in Figure 1.

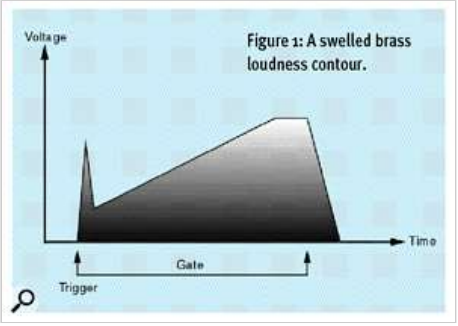

Figure 1: A swelled brass loudness contour.

Now, let's look at the common 4-stage ADSR envelopes offered by all the synths in the 'classic' collection mentioned above (see Figure 2,) and ask ourselves why we can't use these to recreate the desired brass sound. The problem

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lies not only in the number of stages offered by an ADSR contour generator, but in the large number of other limitations it imposes upon us. Let's try to work out how many of these there are:

Firstly, if you have an ADSR envelope, the voltage at the start of the contour has to be zero. This isn't a problem if you want to synthesize a spit brass sound, but it could prove a limitation with other types of sound. Secondly, with an ADSR, the Attack phase of the contour always moves in a positive direction. Thirdly, the ADSR always reaches its maximum level at the end of the Attack. Fourthly, the Decay is always negative with respect to the Attack. Fifthly (is there such a word as "fifthly"?) the Sustain Level always begins at that level reached at the end of the Decay. Sixthly (now we are definitely on shaky grammatical territory) the Sustain Level is a constant voltage. Seventhly, the Release starts at the Sustain Level. Eighthly, the Release always moves in a negative direction. Ninthly, the Release always ends up back at zero.

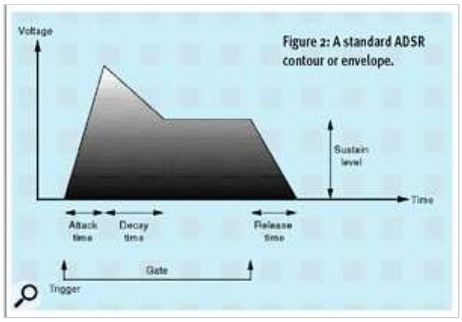

Figure 2: A standard ADSR contour or envelope.

Of these, it's the third and fifth limitations that are most damaging to the spit brass sound shown in Figure 1. This is because the level at the end of the Attack stage is not the maximum, and the Sustain Level is *not* the level at the end of the Decay! So, is that the end of the story? If the most revered synths in analogue history use ADSR envelopes, must we forever live without synthesized brass sections?

Back To The Classics

Of course, this is not the case — and if you read last month's instalment of this series, you'll know of one workaround already (described in principle last month). Using a Control Voltage mixer on a modular synth, you can combine the voltage contours of several simple envelope generators to create more complex multi-stage envelopes, and these could be used to recreate the spit brass contour, for example. However, on an analogue modular, you'd be hard-pressed to create a usefully polyphonic sound.

Fortunately, there are a number of non-modular synths that do not just offer straightforward ADSR generators. One of the most common of these is the Korg MS20. This has two contour generators, one with five stages, the other with three. The simpler of these is a DAR envelope: Delay, Attack and Release. Figure 3 shows this.

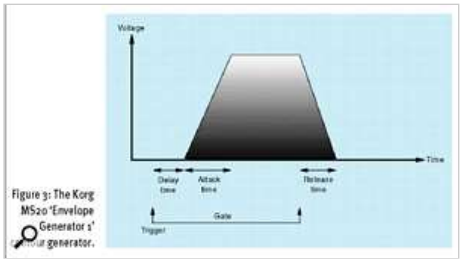

Figure 3: The Korg MS20 'Envelope Generator 1' contour generator.

As you can see, this lacks the Decay stage and user-programmable Sustain Level (the Sustain is always the maximum voltage). But, by way of recompense, the DAR allows you to program a Delay that determines a length of time before the contour is initiated after the start of a note. This is particularly useful, for example, when creating delayed vibrato (we'll come back to vibrato in a couple of months).

Anyway, the second MS20 contour generator is even stranger than the DAR. This is an ADSHR, where the 'H' stands for Hold. If you look at Figure 4 you'll see that the Sustain Level is... um, sustained for a time after the Gate is released. A common use for this would be to hold a note well after you release the key, maybe while you prepare your hands for the next task at hand (remember, Korg released the MS20 before sustain pedals were common on monosynths, and well before MIDI or many of the other performance facilities that we now take for granted). Despite this, the MS20 is

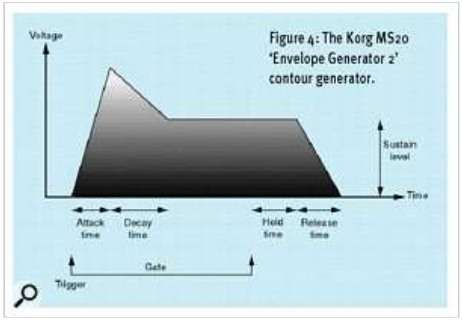

Figure 4: The Korg MS20 'Envelope Generator 2' contour generator.

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clearly incapable of generating the contour from Figure 1.

Maybe we should look back a little further in Korg's history. The Korg 700, 700S, 770 and 800DV were perhaps the strangest monosynths ever produced. These shared a style of contour generator that is hardly recognisable in today's homogeneous world. With just two sliders sharing the names Attack/Slow, and Percussion/Singing, and with switches for Sustain On/Off, or (depending upon model) Percussion/Sustain/Hold, these were nonetheless capable of all the common ADSR contours, although with less control over the Decay and Release times. Unfortunately, despite their quirks, these were also unable to generate the type of contour we're seeking.

Hmm... perhaps we should look elsewhere for our spit brass patch. Surely the two greatest Yamahas of all time can do what we want? How about the mighty GX1? For no less than £40,000 in 1975 (well over £250,000 at 1999 values) you might have expected something a little special. Well... yes and no. Each of the GX1's voices had two contour generators, one permanently patched to the amplifier, the other to the dual high-pass and low-pass filters. But, yet again, the loudness contour was just a conventional ADSR! The filter contour was, however, different from anything we have discussed so far. This offered an Initial Level control, an Attack Level control, plus more conventional Attack, Decay, and Release times (see Figure 5). It looks superficially similar to the ADSR, but has a number of significant differences. For example, the Initial Level is not necessarily the minimum level at which the Release stage terminates. Also, there is no defined Sustain stage — the Decay decreases exponentially to zero volts, which (at least, on long notes) is the level until the key is released. Nevertheless, the GX1 is no more capable of the 'spit brass' sound than any of the other synths discussed so far. Not surprisingly, the mighty CS80 (the cheaper 'son of' the GX) shares this structure. Powerful it is, but not all-encompassing. So where do we turn now?

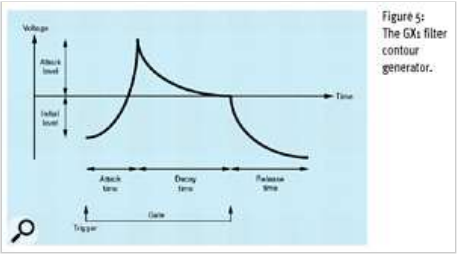

Figure 5: The Yamaha GX1 filter contour generator.

How about the best-known analogue of all, the Minimoog? No... that's just got a pair of ADSD contour generators, wherein the Release time equals the Decay time, or is zero. So what about the ARP Odyssey and its soul-mate, the Octave Cat? No, again. These have an ADSR and a simple AR. In fact, the solution to the problem lies with none of the so-called 'classic' analogues...

From Dinosaurs To Digits

All the instruments we have mentioned so far this month used simple knobs or sliders to change resistances within, and therefore control the responses of, their circuits. These responses could be, for example, the pitches of the oscillators, the cutoff frequencies of filters, or the time constants in various stages of their contour generators.

Nevertheless, lots of these synths were analogue/digital hybrids that used microprocessors to control many of their memory and synthesis functions. Sure, they had knobs, but they also had analogue-to-digital converters that translated the voltages they controlled into numbers. These numbers were converted back into voltages to generate a sound, but it was the numeric form that the instrument saved in its memory, and which you could recall at the touch of a button.

As you know, microprocessors handle numbers as a series of 0s and 1s known as a binary number. The number of digits used in this number is the number of 'bits', and it is this that determines the accuracy with which you can resolve any given parameter. Many hybrid synths used five bits to describe important values, thus offering just 32 possible values. Even the better and more expensive digitally controlled analogue synths used only seven bits, offering just 128 possible values for the parameter. This was quite a limitation — whereas the original knob may have been capable of thousands of discrete settings, the microprocessors constrained you to just a handful of values. Indeed, the memory chips used in early synths were very expensive, so manufacturers were keen to use as few bits as possible. By doing so, they could offer more patch memories for the same number of chips, and minimise the battery power needed to keep the memory 'alive' when the keyboard was switched off.

Of course, it didn't take long for manufacturers to realise that players didn't need dozens of knobs to program these machines. Or, to be more cynical, it didn't take long for manufacturers

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to realise that they could cut their costs if they removed all the expensive knobs and sliders. Instead, they could assign an identification number to each sound parameter, and it then became the player's job to request the appropriate parameter before editing it using a single knob or a pair of Up/Down buttons. Consequently, the mid-'80s became the heyday of Digital Parameter Access (DPA) synths, from the cheap-and-cheerful Korg Poly 800, to the... well, cheap-and-cheerful Roland Alpha Junos. And believe it or not, it is these synths that provide the solution we've been looking for.

And The Answer Is...

It's a strange quirk of fate that the transition from purely analogue to digitally-controlled-analogue architectures made possible many of the facilities that we take for granted on modern instruments. Freed from the constraints of expensive control panels, manufacturers were able to extend the specifications of many parts of the synthesizers' architectures.

For example, the Korg Poly 800 and its rackmount sibling the EX800 offer no fewer than three contour generators, each with six parameters controlling five stages (see Figure 6).

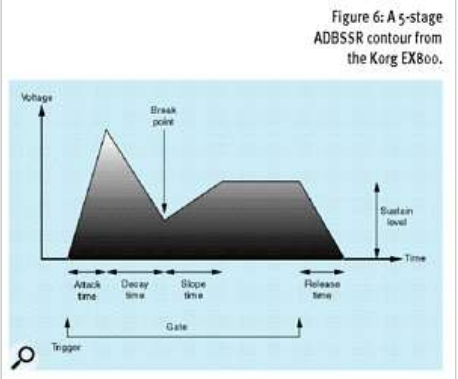

Figure 6: A 5-stage ADBSSR contour from the Korg EX800.

On the Poly 800 and EX800 these are called DEGs — Digital Envelope Generators — because their shapes are calculated in real time by a microprocessor before being converted into analogue voltages. As you can see from Figure 6, these DEGs offer a far greater range of contours than the simple ADSR, if only because the Break Point can be above or below the Sustain Level. Nevertheless, most of the limitations described earlier in this article still apply. In particular, the maximum level still occurs at the end of the Attack stage. Furthermore, the Poly 800 and EX800 are two of the DPA synths that use just 5-bit words to store their parameter values, so each of the six parameters in the contour can take a value only between 0 to 31. Consequently, if you want an Attack time that seems to lie, say, somewhere between 18 and 19, you're stuffed.

So, finally, let's turn to the Roland Alpha Juno series, a family of synths that receive more than their fair share of opprobrium, and which are grossly underrated by almost every analogue synth fanatic on the planet. A number of things make these little Rolands special, and one of these is their contour generator. This allows you not only to determine four time settings, but no fewer than three levels, making it dramatically superior to the three time settings and one level of the ADSR. As you can surmise from Figure 7, the Alpha Juno has no difficulty creating the basic ADSR shape — and before we move on, there is an important lesson here. By choosing the parameters of a 5-stage contour carefully, you can make it look similar or even identical to a 4-stage ADSR. In fact, however many stages the contour generators on your synth have, you can usually recreate the contours of a envelope generator with fewer stages. Sure enough, if you set the Sustain Level of a 4-stage ADSR to its maximum, you always generate a 3-stage trapezoid contour, no matter what the A, D and R values may be. Similarly, setting the Sustain Level to zero and making the Release Time equal to the Decay Time recreates the 2-stage AD and AR contours.

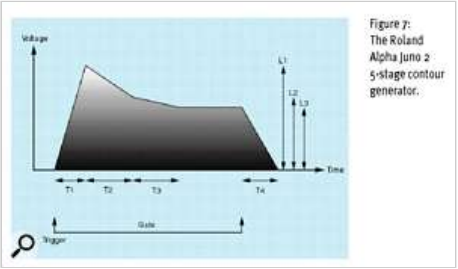

Figure 7: The Roland Alpha Juno 2 5-stage contour generator.

But, of course, the extra stages and levels are there to allow you to create new contours that take us well beyond the capabilities of ADSRs — and you can see two of these in Figure 8 and Figure 9. As you can see, Figure 8 duplicates the 5-stage contour of the EX800. This is a significant advance over the ADSR because we have used L2 (Level 2) as the Break Point in this contour. But we have still overlooked the 'L1' parameter, the one that allows the level at the end of the Attack to be other than the maximum amplitude of the contour. So let's reduce L1 and adjust the other parameters to create Figure 9. Lo and behold... it's our spit brass contour from Figure 1!

So, here's this month's first Synth Secret:

Increasing the complexity of the contour generators adds many possibilities for more detailed sound creation, without precluding the creation of simpler sounds.

Why Are We All Here, Anyway?

Finally, I would like to point out that the backlash against Digital Parameter Access has been the fuel behind the current 'retro' craze for all things knobby and controllable. Perversely, many of the over-priced fashion statements that cash in on this craze ("my Jupiter 6 and Prophet 600 are analogue man, real music, not like that digital rubbish...") have digital memories and quantised parameters, and are therefore analogue/digital hybrids. This means that their parameters are limited by the resolution of their processing systems. Furthermore, many of the most sought-after analogue synths use their micro processors to generate their LFOs and envelopes digitally and, in many ways, are barely analogue at all! If you're interested in synthesis, the best way to deal with the digital vs. retro debate is to ignore it, and keep in mind that the reason these instruments exist is to craft different sounds and make music with them. In short:

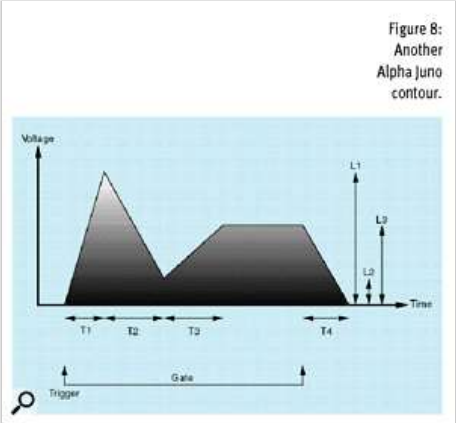

Figure 8: Another Alpha Juno 2 contour.

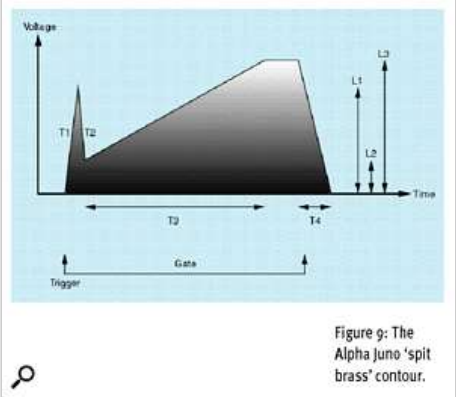

Figure 9: The Alpha Juno 2 'spit brass' contour.

Don't become carried away by the current craze for vintage synths or their DSP-generated descendants. Think about the type of sounds you want to generate, and choose your instrument carefully so that you can produce them.

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