The Time Machine

Many have dreamed of a time machine. Traveling back in the past and mixing history with present ... In the world of DSP this is just a reality: Time Delay. The audio delay line is almost the 'Swiss army knife' for sound manipulation. The majority of the effects in modern hardware and software use one or more time delays. Also in the so-called 'physical modelling' synthesis according to the 'wave guide' principle, such a time delay element forms the heart of the system.

Static time delay: canons, echoes, delays, resonances and filtering
The first electronic version of the echo pit is the tape recorder. The recording head places the signal on tape, which is played back later via the playback head. How much that is equal is determined by the distance between the two heads and by the belt speed. We now introduce a mixer and connect it as follows: signal to mixer input 1, tape recorder output to mixer input 2 and then mixer output to tape recorder input. We then obtain, depending on the mixer settings, a number of echoes, which become increasingly weaker.

In the sixties and seventies, we see a number of echo devices that have been constructed according to this principle. The time intervals between successive delays in such a system based on the tape recorder are limited to relatively limited time intervals; the tape speed and the distance between the recording and reproducing head.

Major time delays were realized by applying two identical tape recorders. The band ran from the first recorder that recorded to the second recorder that was playing. By determining the distance between the two recorders, a large to very large time delay could easily be realized. The delay time could become so great that the repetitions were no longer experienced as echoes, but occurred as a canon.

The American composer, pianist, improviser and soprano saxophonist Terry Riley in particular has applied this tape delay principle and worked it out musically. Also in pop music this 'canon machine' is frequently used by the guitarist Robert Fripp. This technique was also named after him in pop music as 'Frippertronics'.

At the beginning of the nineties, completely electronic delays appeared on the market that were no longer based on the magnetic tape or disc principle. The new technique was the so-called 'bucket memory'. In fact, a (large) number of analog memory elements (capacitors) housed in an Integrated Circuit. The arrival of this made it possible to realize very small time delays for the first time, even less than a millisecond. If we now mix the dry signal with the delayed version, completely new phenomena are formed for observation: resonance and comb filtering, for example.

Dynamic time delay: Doppler, siren, vibrato, rotating speaker, panning, chorus and flanging

Doppler
With the appearance of these fully electronic time delays, dynamic time delay comes within reach. The delay time is then no longer a static datum, but can be modulated. For example, by a low-frequency oscillator (LFO). With this, completely different sound phenomena emerge. For example, if we only listen to the delayed signal. For example, in one second we let the set delay time gradually become shorter and the next second gradually decrease to the initial delay. Depending

on the modulation depth of the propagation time, this can occur as the Doppler effect, which we all know from the fast-moving police car with siren on.

Vibrato, Leslie, chorus
By now making the modulation frequency faster, between 4 and 7 Hz and the modulation depth, we obtain a vibrato effect. With multiple parallel time delays, beautiful Leslie and chorus effects can be simulated. This was first applied by Ir. T. van der Kooy, at the time head research of Eminent-Solina in Bodegraven the Netherlands in the 'Orbitone' system, a very convincing electronic simulation of the Leslie speaker system. A further development of Orbitone can be found in the Solina 'Strings-Ensemble' as the rich sounding unison strings effect. This made the instrument instantly famous and you found it in almost every studio in the seventies. As a result, it was imitated very quickly after the introduction by Elka and Hohner, albeit in simplified versions, which sounded less convincing than Van der Kooy's 'Strings-Ensemble'. This principle, the application of multiple parallel time delays, for obtaining a chorus effect has been further elaborated by Lexicon in the LXP1 processor as a preset 'Chorus 2' by using twelve comb filters with mutual fundamental frequency ratios according to Equal Tempered Tuning (see Lexicon LPX-1 Chorus 2 jpeg).

Practice
The following list of examples after Craig Anderton give starting points for the realization of various distinct effects:

Static time delay
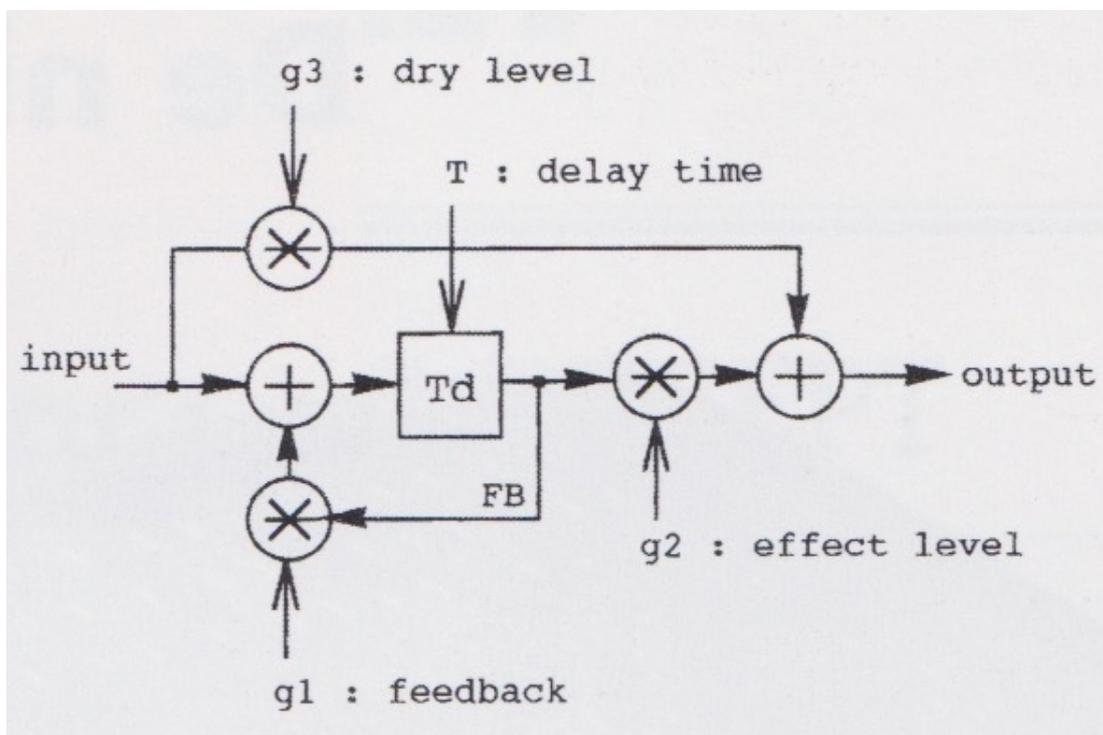
Canon
time delay feedback dry-wet
> 1000ms 0% - ± 89% 60% -40%

Echo
time delay feedback dry–wet
250–1000ms ± 75% 60% –40%

Sixties slapback echo/delay
time delay feedback dry–wet
70ms +10% – + 60% 60% –40%

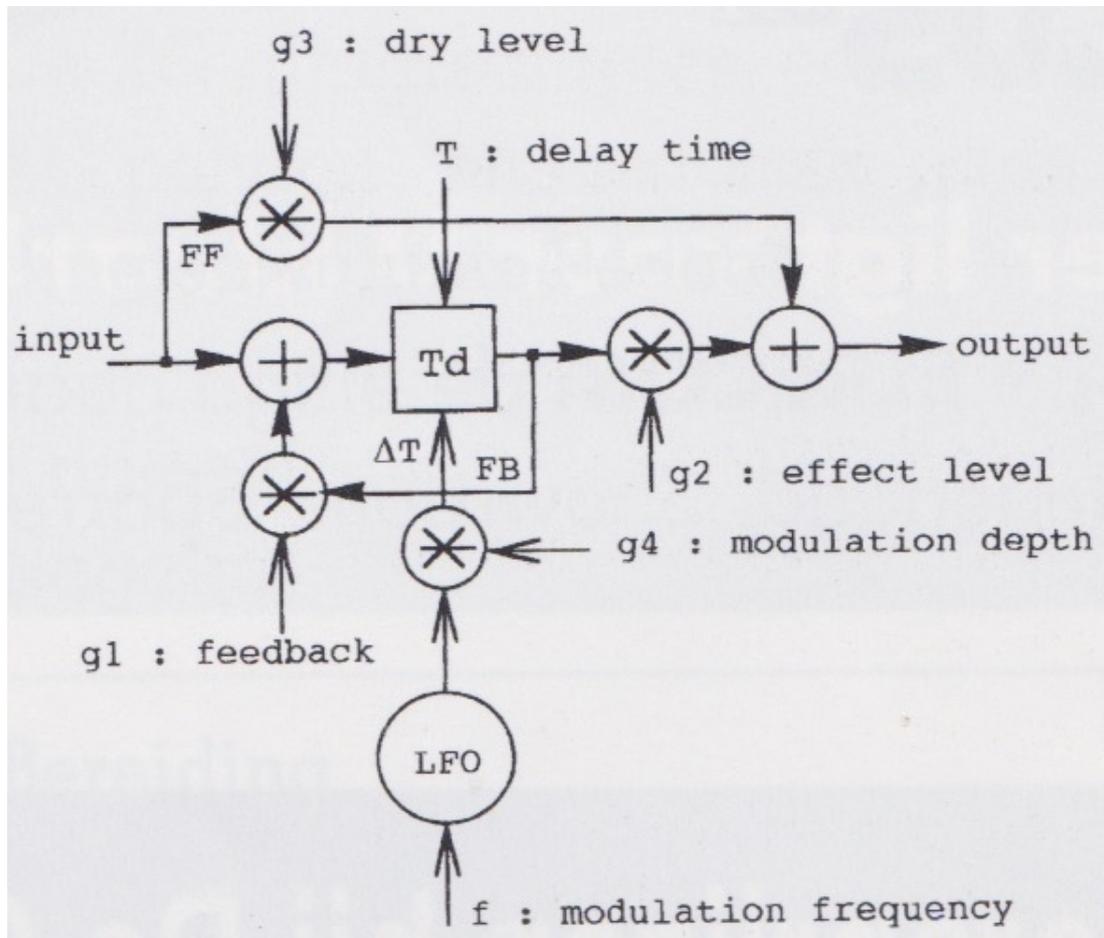**Bathroom**
time delay feedback dry–wet
20–30ms ± 75% 50% –50%
Comb filtering
time delay feedback dry–wet
0,1ms –10ms 0% 50% –50%

Resonances
time delay feedback dry–wet
0.1ms –10ms ± 90% – ± 69% 60% –40%

Dynamic time delays

Vibrato
time delay feedback modulation depth modulation frequency dry-law
10ms 0% 15% 4-8Hz 100% -0%

Rotating speaker/Leslie
time delay feedback modulation depth modulation frequency dry-law
10ms 0% 20% 7-10Hz 50% -50%

Chorus
time delay feedback modulation depth modulation frequency dry-law
10-25ms ± 25% 30%> 1Hz 50% -50%

Flanging
time delay feedback modulation depth modulation frequency dry-law
0.1-5ms ± 50% 100% 0.2Hz 50% -50%

Doubling
time delay feedback modulation depth modulation frequency dry-law
25ms ± 50% 0% 20% 1-2Hz 50% -50%

Further reading
Pimp your loops, Ernst Bonis
Article on this website

Internet
Terry Riley, A Rainbow In Curved Air
https://www.youtube.com/watch?v=hy3W-3HPMWg

Terry Riley, Shri Camel
https://www.youtube.com/watch?v=ZfHmEblM1Dk

Terry Riley, Shri Camel, Desert Of Ice
https://www.youtube.com/watch?v=C7R6iEQUeMA

Robert Fripp, Frippertronics
https://www.youtube.com/watch?v=k5HannQM364