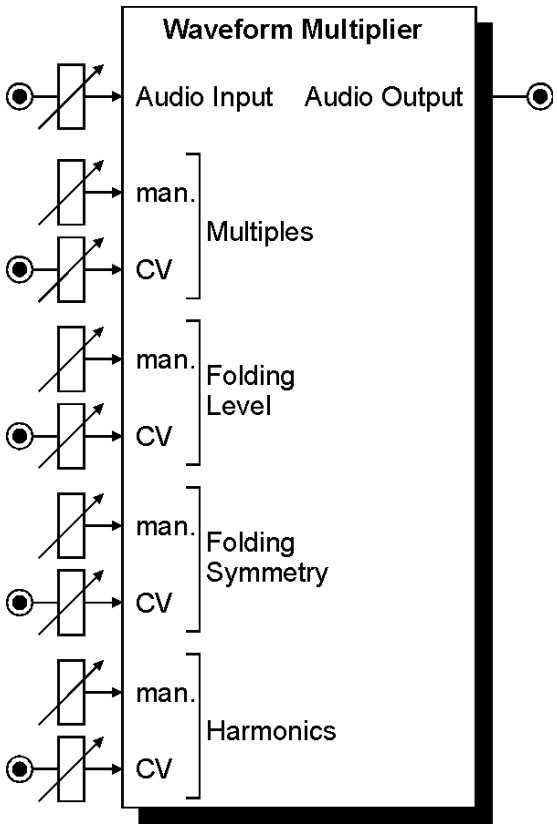
1. Introduction



Module A-137 is a **Voltage Controlled Waveform Multiplier**. The basic idea of a wave multiplier is to **multiply the waveform** of an incoming signal (e.g. triangle from a VCO) **within one period**. This leads to **additional harmonics**. The period and consequently the **pitch** of the signals remains **unchanged** - in contrast to frequency multiplication e.g. with the PLL module A-196. The A-137 works as a kind of "***inverse low pass filter***", i.e. it adds a lot of harmonics to the incoming signal. Consequently the best results are obtained with signals that contain none or only a few harmonics (e.g. triangle or sine waveforms). The A-137 can be used with signals rich in harmonics too (e.g. saw) but the effect is not as remarkable as for triangle or sine waves.

The A-137 is a very sophisticated wave multiplier that offers much more features, more controls and more waveform manipulations than other wave multipliers available so far. In addition all **four parameters** are both manually adjusted and **controlled by external voltages**:

- **Multiples:** number of waveform multiplications
- **Harmonics:** adds more harmonics similar to the resonance/emphasis control of filters
- **Folding Level/Symmetry:** value and symmetry of the upper/lower folding level

2. Basic principles

The signal is processed by a standard linear VCA and 4 so-called *wave folding stages*. The amplification of the VCA is identical with the *Multiples* parameter. This is the working principle of the folding stages: As soon as the signal goes beyond the *upper* resp. below the *lower folding level* the signal is *reflected* resp. *folded back*. The values for upper and lower folding level are derived from the input parameters *folding level and symmetry*. Both can be adjusted manually and controlled by an external control voltage (CV). *Folding Level* determines the distance between the upper and lower folding level, *Folding Symmetry* the position of both levels relating to the zero line. The internal upper and lower folding level are calculated by adding resp. subtracting the voltages for *Folding Level* and *Folding Symmetry* (refer to fig. 3).

The working principle of one stage by means of a triangle signal is shown in fig. 1. The upper picture shows the incoming signal. The areas to be reflected are filled black. The lower picture shows the output signal of the stage. In this example the symmetry is slightly positive and the reflected areas are not symmetrical.

Fig. 2 shows the folding function of three stages. The amplification (i.e. the *Multiples* parameter) is increased for the succeeding pictures to see the effect of increasing *Multiples*. Stage 4 is not shown because of clearness.

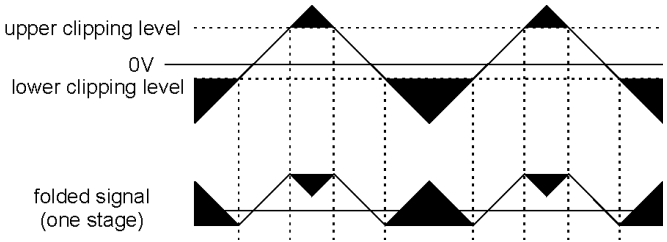


Fig 1: Folding function for one stage

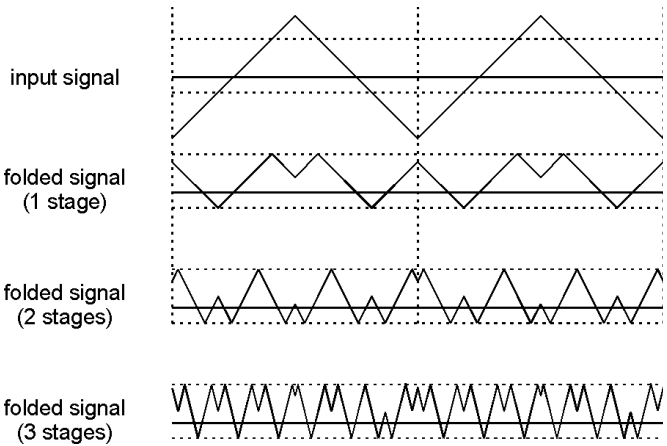


Fig 2: Folding function for three stages

As the amplification resp. the *Multiples* parameter increases even the peaks of the folded signal reach the folding levels of the succeeding stage and the signal is folded once again as shown in fig. 2. As the module contains 4 folding stages up to 8 foldings are possible (4 at the upper and 4 at the lower clipping level). Consequently the maximum multiplication factor is 9 (8+1). If a second A-137 module is added even more multiplications are possible.

The *Harmonics* parameter sharpens the waveform slopes and adds some overshoot at the edges - a little bit like the resonance resp. emphasis function of a filter. Internally the harmonics feature is realized by an additional VCA for each folding stage.

Fig 3 shows the complete schematics of the A-137 module. For each of the four parameters *Multiples, Folding Level, Symmetry* and *Harmonics* a manual control and an external control voltage input with attenuator is available.

The external control of each parameter can be realized with the usual modulation resp. CV sources: LFO, ADSR, random voltage, MIDI-to-CV, Theremin, ribbon controller, joy stick, foot controller and so on. Of course simultaneous control of several parameters with different CV sources is possible (e.g. *Multiples* controlled by and ADSR and *Harmonics* by a LFO).

As the signals within the A-137 are fully DC coupled the module can be used to process control voltages too.

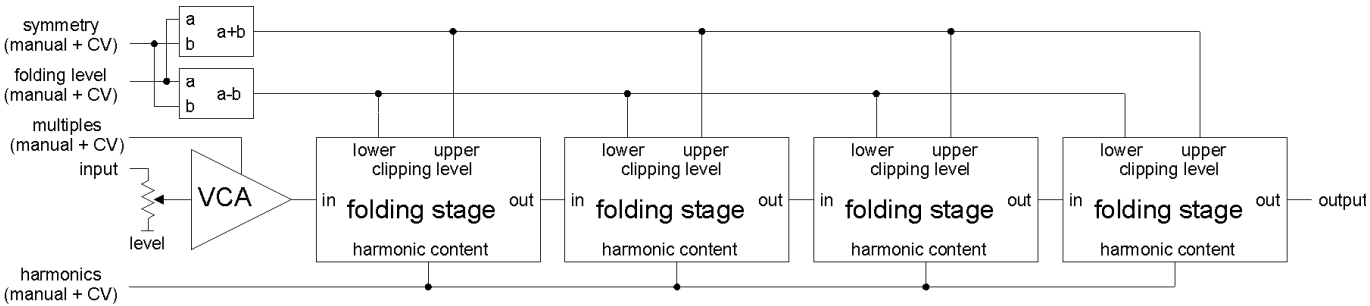
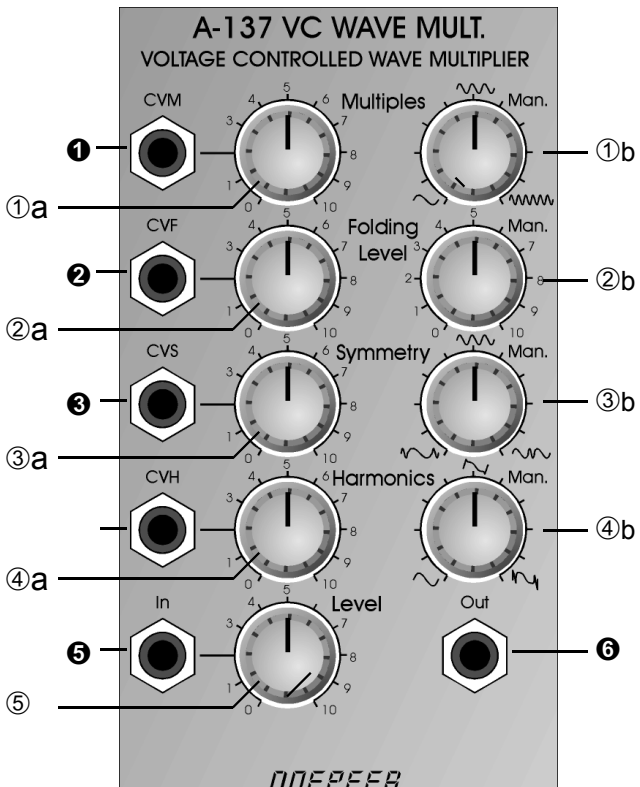


Fig. 3: Overall view

3. Overview



Controls:

①**a CV Multiples**:	Attenuator for CV input ❶
①**b Man. Multiples**:	Manual *Multiples* control
②**a CV Folding Level**:	Attenuator for CV input ❷
②**b Man. Folding Level**:	Manual *Folding Level* control
③**a CV Symmetry**:	Attenuator for CV input ❸
③**b Man. Symmetry**:	Manual *Symmetry* control
④**a CV Harmonics**:	Attenuator for CV input ❹
④**b Harmonics Man.**:	Manual *Harmonics* control
⑤ **Level**:	Input level control

Inputs / Outputs:

❶ **CVM**:	CV input *Multiples*
❷ **CVF**:	CV input *Folding Level*
❸ **CVS**:	CV input *Symmetry*
❹ **CVH**:	CV input *Harmonics*
❺ **In**:	(Audio) input
❻ **Out**:	(Audio) output

4. Controls

①**a CVM** (knob) / ❶ **CVM** (socket)
①**b Manual Multiples** (knob)
This group of elements is responsible for the *Multiples* parameter, i.e. the number of waveform multiplications within one period (range 1...9).

②**a CVF** (knob) / ❷ **CVF** (socket)
②**b Manual Folding Level** (knob)
This group of elements is responsible for the *Folding Level* parameter, i.e. the distance between upper and lower folding level.

③**a CVS** (knob) / ❸ **CVS** (socket)
③**b Manual Symmetry** (knob)
This group of elements is responsible for the *Symmetry* parameter, i.e. the asymmetrical shift of upper and lower folding level relating to the zero level.

④**a CVH** (knob) / ❹ **CVH** (socket)
④**b Manual Harmonics** (knob)
This group of elements is responsible for the *Harmonics* parameter, i.e. the sharpening of the waveform slopes and the addition of overshoot at the edges similar to resonance resp. emphasis function of a filter.

The following is valid for each of the 4 parameter groups:

Each parameter has available a manual control knob (①b/②b/③b/④b) and an external control voltage input (❶/❷/❸/❹). Each external CV input is equipped with an attenuator (①a/②a/③a/④a) that allows to adjust the effect of the external CV to the parameter in question.

The required control voltage difference at the sockets ❶ to ❹ is about 5V to reach all available settings, i.e. about 0...+5V with all attenuators set to it's maximum and all manual controls to it's minimum positions.

⑤ **Level** (knob) / ❺ **In** (socket)

This is the audio input of the module (e.g. triangle output from a VCO) and the corresponding level control. Control ⑤ has the same effect as the *Multiples* parameter as it is connected in series with the VCA that controls the *Multiples.*
Level control ⑤ is adjusted so that the maximum effect is obtained while passing through the complete *Multiples* range (e.g. by turning knob ⑤ from fully counterclockwise to fully clockwise). If the input level is too small not all waveform multiples will be reached. If the level is too high the maximum waveform multiples are reached even for middle positions of control ⑤ and the output signal only distorts for higher settings of control ⑤. But this may be a desired behaviour so that the level control can be set intentionally to higher values.

❻ **Out** (socket)

This is the audio output of the module. The output signal can be processed by other A-100 modules like filters, VCAs, phaser, reverb or a second A-137.

5. User Examples

not yet ready