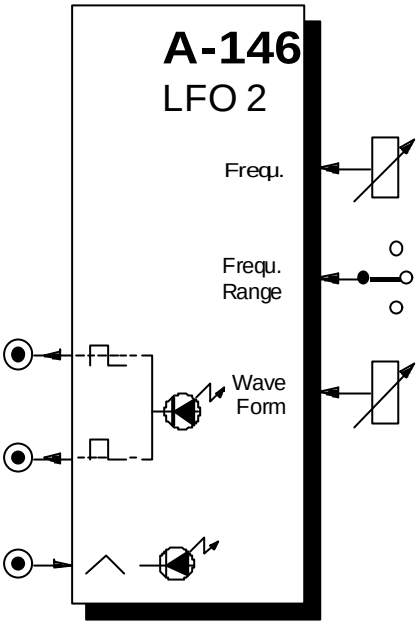


1. Introduction

Module **A-146 (LFO 2)** is a **Low Frequency Oscillator**, which produces periodic control voltages over a wide range of frequencies.

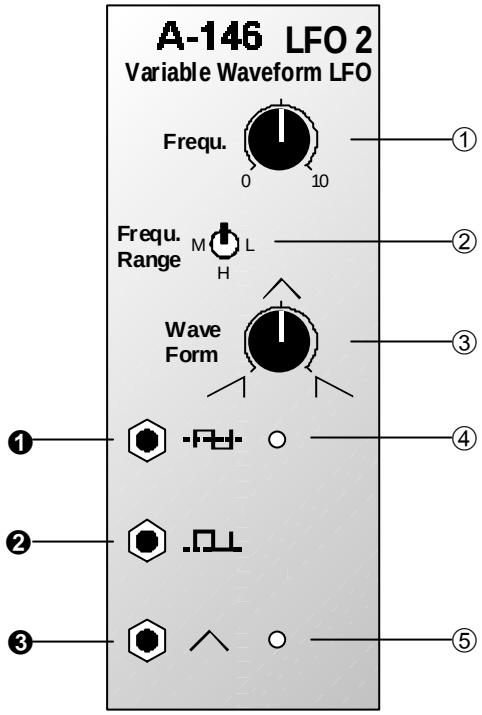
The LFO can be used as a **modulation source** for a series of modules (for instance pulse width and/or frequency modulation of a VCO, modulation of a VCF cut-off frequency, amplitude modulation with a VCA).

Three outputs are available, with different waveforms: **sawtooth / triangle; square wave, and positive-voltage square wave.**

The **waveform** is continuously adjustable from rising sawtooth, through triangle to falling sawtooth. The same control affects the **pulse width** of the square wave.

A three-way switch can select one of three frequency ranges, spanning from one cycle every few minutes, at the lowest, up to audio frequency at the highest.

2. LFO - Overview



Controls and indicators:

1 **Frequ.** : frequency control

2 **Frequ. Range** : switch for selecting frequency range

3 **Waveform** : control for adjusting the waveform or pulse width

4 **LED** : square wave frequency indicator

5 **LED** : sawtooth / triangle wave frequency indicator

In / Outputs:

! : output for normal square wave

" : output for positive square wave

§ : output for sawtooth / triangle wave

3. Controls and indicators

1 Frequ.

Use this control to set the LFO's **frequency,** within the range set by 4.

2 Frequ. Range

Use frequency range switch 4 to select a suitable range from the three available :

- **L** (low): up to several minutes per cycle
- **M** (medium): normal LFO range
- **H** (high): audio range

3 Waveform

The waveform of the signal at output § can be continuously varied with this control, from **rising sawtooth** (fully left) through **triangle** (centre position) to **falling sawtooth** (fully right). The same control alters the pulse width of the rectangle wave at outputs ! and ".

4 LED • 5 LED

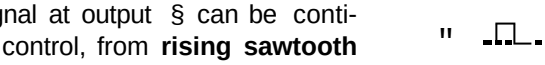
LEDs 4 and 5 indicate the frequency rate of the waveforms at outputs ! to §.

H If the LFO frequency goes above about 15 to 20 Hz, our persistence of vision means that the LEDs look permanently on.

4. In / Outputs

! 

Thi s socket is the output for the **normal** (positive / negative amplitude - ± 2.5 V) **square wave**, whose frequency is displayed by LED 4.

" 

This socket is the output for the **positive square wave** (amplitude + 5 V), whose frequency is displayed by LED 4.

§ ^

This output, depending on the setting of control 3, sends out a rising sawtooth, triangle or falling sawtooth waveform (amplitude ± 2.5 V) whose frequency is indicated by LED 5.

5. User examples

The LFO can be used for all sorts of modulation:

- **LFO - VCA**
  Modulation of the amplifier produces periodic changes in **loudness (Tremolo)**

- **LFO - VCF**
  Modulation of the cut-off frequency produces periodic changes in **timbre (Wah-Wah)**

- **LFO - VCO (PWM)**
  Modulation of the pulse width produces periodic changes in **timbre (Pulse Width Modulation)**

- **LFO - VCO (FM)**
  Modulation of the VCO frequency produces periodic changes in **pitch (Vibrato)**.

The above effects occur with LFO frequencies in the **sub-audio range**. Once the LFO gets into the audio range, timbral changes always occur. Examples and further notes can be found in the manuals for the respective modules.

LFO as timing generator

Besides modulation, the LFO can also be used as a timing generator, providing triggers, for instance, to control the A-160 clock sequencer (see user examples for the A-160 and A-161).

A-146 special features and their uses

Compared with the A-145 "standard LFO", the A-146 has the following particular features and uses:

- **Variable waveform**
  The adjustable nature of the sawtooth / triangle waveform gives you great flexibility in controlling **slow filter sweeps** or **tremolo**. Whereas the rising sawtooth on the A-145 ends abruptly, on the A-146 you can produce whatever slope on the falling edge you want, by setting the control 3 at various positions around nine o'clock.

  The adjustable envelope also gives flexible control of **Amplitude Modulation** (see A-130 user examples) and **Frequency Modulation** (see A-110, A-111 user examples) in the **audio range**, to produce new timbres. Whereas the overtone-rich sawtooth waveform produces lots of sidebands (see the A-110 manual), moving the control towards the triangle wave setting (12 o'clock) reduces the sidebands, because of the triangle wave's comparative lack of overtones.

- **Variable pulse width**
  In using the square wave for AM or FM in the audio range, it's possible to control the **timbre** by adjusting the pulse width, because the amount of overtones (and sidebands) present is directly related to the width of the pulse.

  The A-146's pulse width control also comes in useful when using the LFO as a **trigger or gate generator** for repeated sequences. The patch in Fig. 3 is an example: the envelope (set to a duration $\mathbf{t_G}$, which is shorter than the LFO's half-cycle), gives the rhythm a more percussive feel. Whereas with the A-145, an extra A-162 trigger delay module would have to be used to adjust the gate duration (Delay = 0, Length =...) to $\mathbf{t_G}$, that's not the case with the A-146: you simply have to adjust the pulse width.

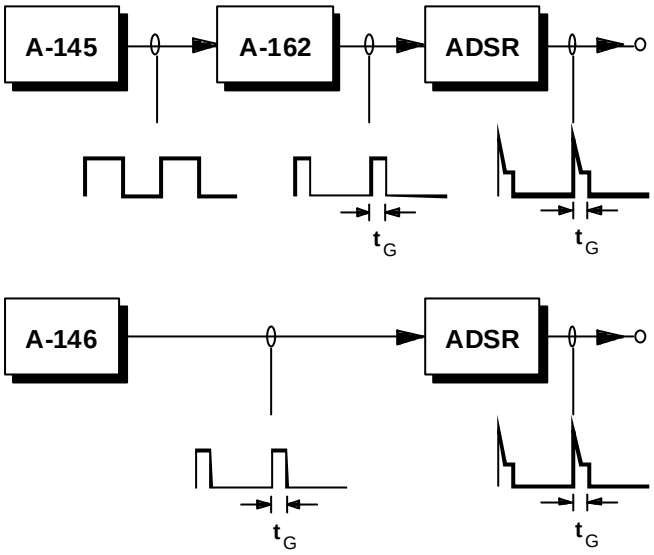


Fig. 3: Producing gate pulses of variable duration

- **Positive square wave output**
  This output has the useful function of being able, unlike a normal positive/negative square wave, to create **pitched repeats which stay in tune.**

In Fig. 4 on page 7, the pitch of a VCO is controlled by a CV from a keyboard, but also from the square wave output of the A-146, via input CV2. The voltage at CV2 is set with the attenuator to exactly 1 volt.

With the **normal positive/negative square wave** modulating the pitch, the result is notes that are annoyingly **out of tune** with the keyboard (see Fig. 4, top right of diagram).

If instead you use the **positive square wave**, the octave jumps are completely **in tune** with the keyboard (see Fig. 4, bottom right of diagram).

You can use this characteristic in your music, for instance to produce a **mandolin effect**. The interval of the strummed notes is set with the VCO's CV2 attenuator, and the speed of repeat is set by the frequency control on the A-146.

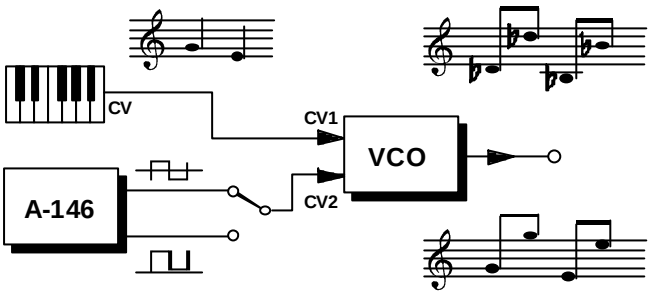


Fig. 4: Producing pitched repeats that are completely in tune with the keyboard.

6. Patch-Sheet

The following diagrams of the module can help you recall your own **Patches**. They're designed so that a complete 19" rack of modules will fit onto an A4 sheet of paper.

Photocopy this page, and cut out the pictures of this and your other modules. You can then stick them onto another piece of paper, and create a diagram of your own system.

Make multiple copies of your composite diagram, and use them for remembering good patches and set-ups.

P
- Draw in patchleads with colored pens.
- Draw or write control settings in the little white circles.