Review Report

of a Eurorack module

Doepfer

A-145-1 LFO

Module version 2

Document version 1.00

By Garfield Modular

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1 Introduction

Welcome to this report review of **A-145-1 LFO** from **Doepfer**. This module is an **LFO** that has 5 simultaneous outputs and has a pleasant user interface, great for every patch.

For more details, please continue reading the following chapters and paragraphs.

An overall overview and summarise of the module, has been provided in the next chapter 2 - The module summarised. Additionally, the author's own opinion has been provided here.

In chapter 3 - Quick overview & facts sheets it straight away starts with a "quick" overview of perhaps not all but at least about 200 parameters and characteristics (if applicable of course) of the module that's being discussed here in this report review. This chapter just shows the parameters and characteristics with less prose. For a detailed explanation of all parameters and characteristics mentioned, one should check out the chapter 7 - Appendix A – Eurorack module details explanation.

Chapter 4 - User interface experience goes a bit more into the details of the look, touch and impression of the module and of course the user interface experience. For a brief overview without the prose, one might actually like paragraph 3.7 - Look, touch & feel impressions that's very much related to this chapter.

The functionality and the flow diagram of the module has been discussed in more details in chapter 5 - Functionality overview where it might get a bit technical. The reader should note though that this doesn't replace the manufacturer's manual, that is not the goal of this chapter (to be a manual) rather being an add-on information to the module for the reader.

This document discussed so far, a lot of stuff already but perhaps the most important part still hasn't been mentioned. Well indeed, that's to build up the tension, to keep it all till the end exciting ☺. Well, all right then, the last chapter 6 - Audio & sound experience tells the reader a bit more about the audio & sound possibilities and experiences of the module.

How beautiful music can be made with this module or on what kind of sonic crazy adventure one can be taken, that leaves the author up to the musician or the sound engineer that's reading this review! ☺ Having that said, the author still tries to provide a few sound links of some "demo sounds" in this chapter to give at least a rough impression what this module can provide you with.

A side note: the author's intention is to write an as neutral as possible review report, though the writer is a human being too (even if the name is Garfield), so one should keep in mind that at the end it's, though trying to be as neutral as possible, still an own view. This especially applies to the chapters 4 - User interface experience, 6 - Audio & sound experience and of course paragraph 2.1 - Author's own opinion.

No rights can be taken from this review report, neither from typos or wrong mentioned interpretations, translations, wrong source information from websites, or whatsoever.

One should note that this review report about the mentioned module, is made from a hobby perspective and as from such point of view this report review should be seen and experienced. One is of course welcome to provide feedback to the author if a review report should contain typos, missing important information and/or errors.

It should also be noticed that this review report is not a user manual for the module being discussed here. For a user manual of the module please refer to the manufacturer's website or if the manufacturer indeed does publish a user manual, the link can be found here 3.3 - References too.

Having that all said, the writer hopes the person who reads this can see this review report as a kind of help or reference for the module that has been reviewed here and hopes that the user enjoys this module.

TL;DR? → check chapter 2 - The module summarised only
No TL;DR syndrome signs yet? But don't want to spend ages of time either? → you can read the entire review report up till chapter 6 - Audio & sound experience.
You have all the time of the world? Or you want to know more details on the used parameters and characteristics then the entire document is suitable for you ☺

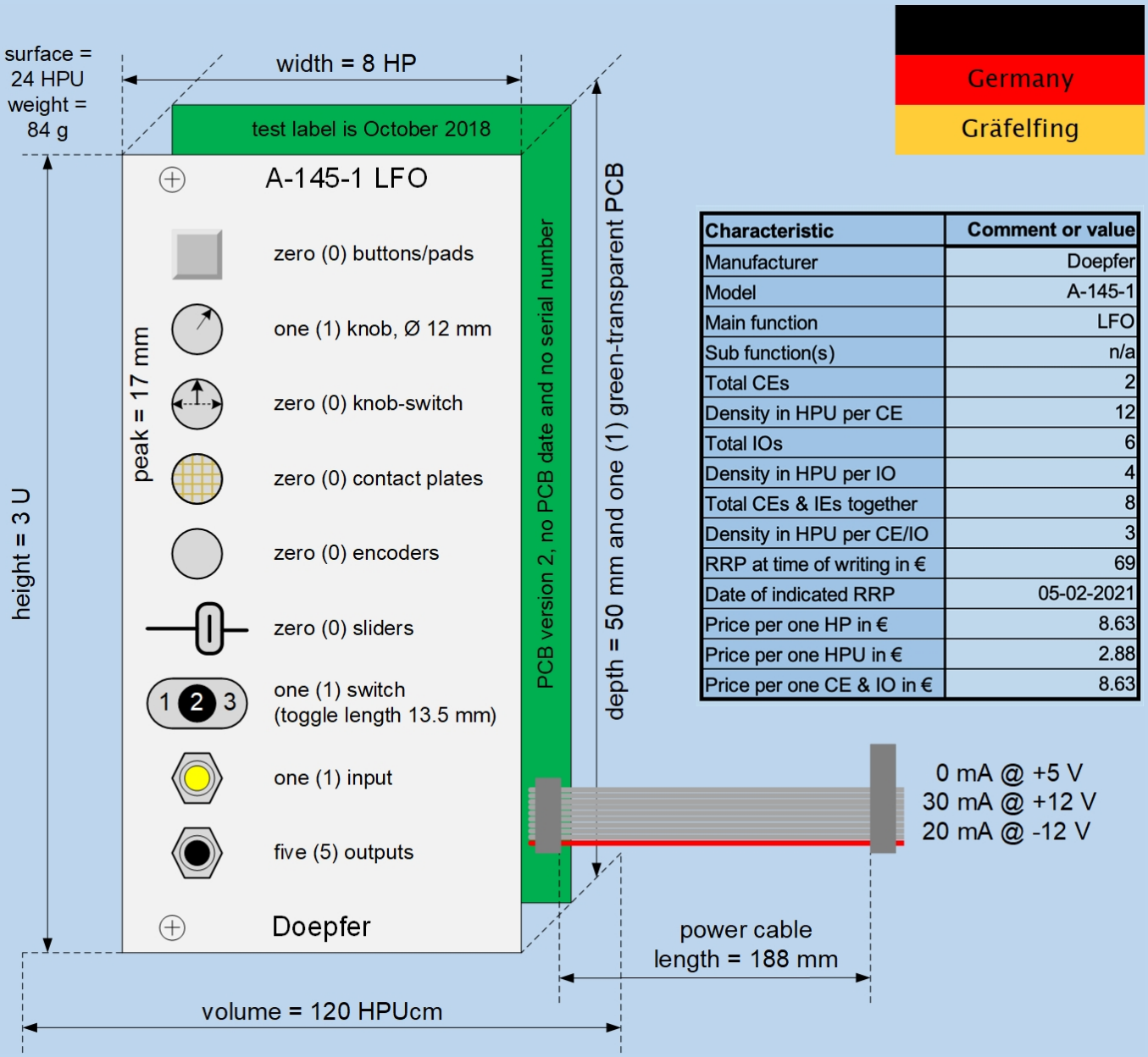
Please enjoy modular synthesizers, keep some lasagne left for me and best regards,

Garfield Modular.

P.S.: Garfield Modular is under the same name once and a while active on https://www.modulargrid.net

2 The module summarised

In the below overview one can find a summarise of the module for a quick overview of the module. After this chapter the extensive details will be further discussed.



Characteristic	Comment or value
Manufacturer	Doepfer
Model	A-145-1
Main function	LFO
Sub function(s)	n/a
Total CEs	2
Density in HPU per CE	12
Total IOs	6
Density in HPU per IO	4
Total CEs & IEs together	8
Density in HPU per CE/IO	3
RRP at time of writing in €	69
Date of indicated RRP	05-02-2021
Price per one HP in €	8.63
Price per one HPU in €	2.88
Price per one CE & IO in €	8.63

Figure 1 – The module summarised

2.1 Author’s own opinion

User interface experience and audio, sonic or sound experience is a rather own experience by the author. The author has tried to be as neutral as possible over the entire document with the exception of the below overview of the module gives a view on how the author experiences this module (see the next figure).

On the next page the author’s rating of the module can be found. Below here, the pros and cons (from an author’s point of view, trying to be neutral though) will be highlighted.

The pros

- ✓ Nice and good to use LFO providing 5 outputs
- ✓ Doepfer's typical good user interface (comfortable and easy to use)
- ✓ A good price-performance ratio

The cons

- × Just a very minor issue, for right-handed persons the toggle switch might be a bit too close to the knob and the patch cables but certainly within acceptable range

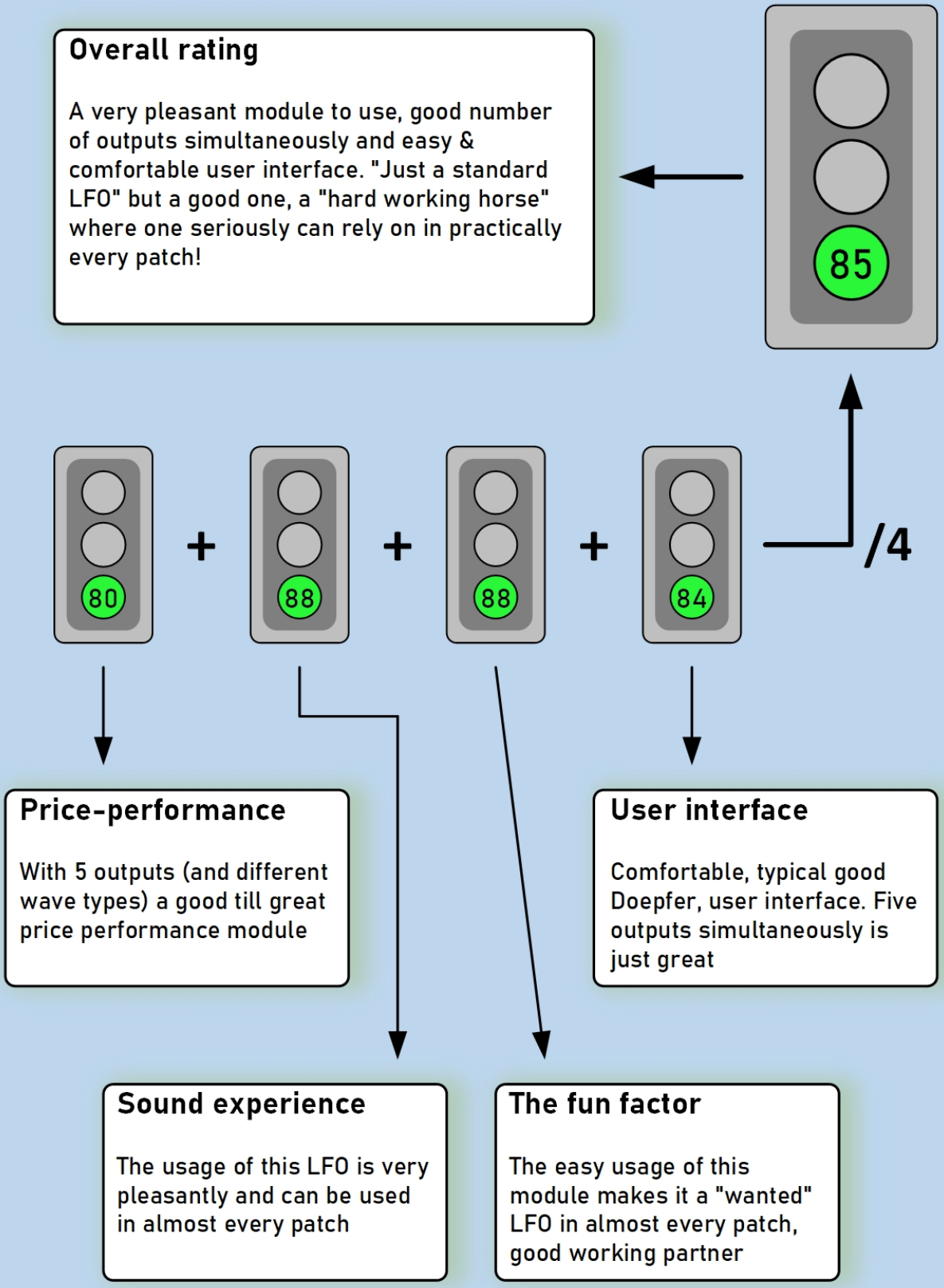


Figure 2 - The module rated by the author

3 Quick overview & facts sheets

For detailed explanations of all the values and parameters indicated and used here, please refer to 7 - Appendix A – Eurorack module details explanation.

3.1 Document details

In the below table the document details of this review report have been displayed.

Characteristic	Comment or value	In unit or comment
Date started the review	05-02-2021	dd-mm-yyyy
Date finished the report	14-02-2021	dd-mm-yyyy
Review Report version	**1.00**	
Review Report number	BP_RR_DP_003	
Latest update date	14-02-2021	dd-mm-yyyy
Appendix A version	**1.03**	

Table 1 - Document details

3.2 General module details

General module details can be found in the below table.

Characteristic	Comment or value
Manufacturer, full name	Doepfer
Manufacturer, short name	Doepfer
Manufacturer, country of origin	Germany
Manufacturer, HQ town	Gräfelfing
Manufacturer, founder(s)	Dieter Döpfer
Module name, full	A-145-1 LFO
Module name, short	A-145-1
Main function	LFO
Sub function(s)	n/a
Version/release	2
In co-operation with	n/a

Table 2 - General module details

3.3 References

Manufacturer page	http://www.doepfer.de/home_e_2019.htm
Manufacturer module's link	In the above link go to Products page → Module overview → A-145-1 Standard LFO
Manufacturer manual link	At the above link scroll down to the English section and click on the A145_man.pdf link/file
Manufacturer YouTube link	There is no manufacturer's video link available
ModularGrid.net module link	https://www.modulargrid.net/e/doepfer-a-145
Garfield Modular review report link	https://garfieldmodular.net/index.php/doepfer/doepfer-a-145-1/
Garfield Modular sound link	See chapter 6 - Audio & sound experience

3.4 Other reference links

In alphabetic order of the reviewer a few links about this particular modular. There aren't many video's available, pure for A-145 only, found one from Pierre Serné. Raul Pena made a few videos combining the A-145-1 LFO with the A-110-1 VCO.

YouTube "Pierre Serné" link	https://www.youtube.com/watch?v=-hENb7AUg5w
YouTube "Raul Pena" links	https://www.youtube.com/watch?v=r51sglRpnrE
	https://www.youtube.com/watch?v=wqWj_LX5SKE
	https://www.youtube.com/watch?v=a2yi58uCEkg
	https://www.youtube.com/watch?v=nRJcVLqQ4p4

3.5 Module measurements

Module measurement details have been reflected in the below “measurements” table.

Module measurements	Value	In unit or comment
Module height	3	U
Module width	8	HP
Module depth	50	mm
Module peak	17	mm
Module front plate thickness	2.3	mm
Module (front plate) surface	24	HPU
Module volume	120	HPUcm
Module full volume	166.3	HPUcm
Module weight	84	gram (g)
Module versus packaging	66.67	%
Weight per one mm	1.7	g/mm
Weight per one U	28	g/U
Weight per one HP	10.5	g/HP
Weight per one HPU	3.5	g/HPU
Weight per one HPUcm	0.7	g/HPUcm
Weight per one full HPUcm	0.51	g/HPUcm

Table 3 - Module measurements

3.6 The original box or packaging of the module

The details of the original box or packaging of the module are provided in the below table.

Characteristic	Comment or value	In unit or comment
Original packaging	carton box	
Main colour(s) of packaging	beige-brown	
Inside packaging of the module	bubble wrap	
Original packaging width	175	mm
Original packaging depth	121	mm
Original packaging height	50	mm
Original packaging volume	1058.8	cm^3
Original packaging weight	126	g
Packaging versus module	150	%
Number of rack screws	2	
Screw colour	chrome	
Screw type	Philips	
Number of washers	n/a	
Washer colour	n/a	
Number of manual pages	n/a	pages
Power cable included?	yes	
Serial number provided?	no	
Sticker included?	no	
Other items	n/a	

Table 4 - Original packaging details of the module

Usually, Doepfer modules in their original boxes are only accompanied by screws and that’s it. No washers, no manual, nothing else but the module in a sealed bubble wrap, the screws in a small plastic zip lock bag and the power cable and that’s it.

3.7 Look, touch & feel impressions

In the below table characteristics of the look, touch & feel impressions can be found regarding the module.

Characteristic	Value	Comment
Front panel material	aluminium	
Front text colour(s)	black	
Logo colour(s)	black	
Background colour(s)	mat silver	i.e. aluminium
Number of LEDs and/or lights	2 red LEDs	
Brightness	medium	
Dimmable brightness?	no	
Can lights be switched off?	no	
Self-illuminating?	no	
Screen	n/a	
Usage's directness	direct	
Patch cables' position	left side only	

Table 5 - Look, touch & feel impressions

For details about the look, touch & feel impressions as well as the user interface experience, please refer to chapter 4 - User interface experience.

3.7.1 Look, touch & feel impressions of the CEs

The characteristics/impressions of the CEs regarding look, touch & feel are reflected in the below table.

Characteristic / CE type	Knob	Switch
Diameter or length in mm	12	13.5
Positions or values	n/a	3
Colour(s)	grey	chrome
Value indicator colour	black	n/a
Push-able?	n/a	n/a
Usage	comfortable heavy	solid switch over
Accessibility	good	good
Other characteristics	n/a	n/a

Table 6 - Look, touch & feel impressions of the CEs

For more information on CEs please also refer to 3.10.2 - Control elements (CEs).

3.8 PCB details

In the below table the PCB details have been reflected.

Characteristic	Comment or value	In unit or comment
Number of PCBs	1	
PCB colour	green & transparent	
PCB version	2	version
PCB model/type/others	n/a	
PCB date	not mentioned	yyyy
Test label date	10 CZ18	
Serial number provided?	no	
Number of vacuum tubes	n/a	
Based on technology	n/a	
µSD card position	n/a	
µSD card capacity, if provided	n/a	GB

Table 7 - PCB details

There is one main PCB that's green on one side and transparent on the other side.

3.9 Power consumption

The power consumption details are provided in the below table.

Characteristic	Comment or value	In unit or comment
Power cable length	188	mm
Power cable type	10	pole wire
Power consumption at -12 V	20	mA
Power consumption at +5 V	n/a	mA
Power consumption at +12 V	30	mA

Table 8 - Power consumption

3.9.1 Power Consumption Indicators (PCIs)

In the following table, rather for fun than for a good meaning or reason, other than perhaps the power consumption per HP, are the power consumption indicators (PCIs) provided. For pricing related values please refer to the 3.11 - Financial Indicators subparagraph.

PCI	Value	In unit
for -12 V, per gram (weight)	238	µA/g
for +5 V, per gram (weight)	n/a	µA/g
for +12 V, per gram (weight)	357	µA/g
for -12 V, per HP (width)	2.5	mA/HP
for +5 V, per HP (width)	n/a	mA/HP
for +12 V, per HP (width)	3.75	mA/HP
for -12 V, per CE	10	mA/CE
for +5 V, per CE	n/a	mA/CE
for +12 V, per CE	15	mA/CE
for -12 V, per IO	3.33	mA/IO
for +5 V, per IO	n/a	mA/IO
for +12 V, per IO	5	mA/IO
for -12 V, per CE & IO	2.5	mA/CE & IO
for +5 V, per CE & IO	n/a	mA/CE & IO
for +12 V, per CE & IO	3.75	mA/CE & IO

Table 9 - Power Consumption Indicators (PCIs)

3.10 Inputs & Outputs (IOs) and Control Elements (CEs)

3.10.1 Inputs & Outputs (IOs)

In the below table the Inputs and Outputs (IOs) are given. The first few rows (Audio up till Trigger) are focussed on mini-jacks (3.5 mm) only; after that possible other connection types follow. The same for the outputs.

Inputs & Outputs (IOs)	Inputs	Outputs	Comment
Audio	n/a	n/a	mini-jacks
CV	n/a	5	mini-jacks
Clock	n/a	n/a	mini-jacks
Gate	n/a	n/a	mini-jacks
Reset/sync	1	n/a	mini-jacks
Trigger	n/a	n/a	mini-jacks
Others	n/a	n/a	
Jack 6.35 mm	n/a	n/a	
MIDI	n/a	n/a	
RJ-45 (Ethernet)	n/a	n/a	
USB	n/a	n/a	
XLR	n/a	n/a	
Total IOs	**1**	**5**	n/a

Table 10 - Inputs & Outputs (IOs) overview

3.10.2 Control elements (CEs)

The number of control elements (CEs) per control element can be found in the below table.

Control Elements (CEs)	Number of CEs
Buttons	n/a
Contact plates	n/a
Encoders	n/a
Knobs	1
Knob-switches	n/a
Pads	n/a
Sliders	n/a
Switches	1
Total CEs	**2**

Table 11 - Overview of the CEs

3.10.3 Total overview of CEs, IOs and densities

The total number of CEs, IOs and also putting them together as a total combination of CEs & IOs can be found in the below table. The module density has been provided too, meaning that per one CE, IO or CE & IO the average HPU has been mentioned.

Totals & Densities	Total	Density in HPU per CE or IO
Total CEs	2	12
Total inputs	1	24
Total outputs	5	4.8
Total IOs	6	4
CEs & IOs together	**8**	**3**

Table 12 - CE & IO totals and densities overview

3.11 Financial Indicators

Beside the price (RRP) and the date that the price has been retrieved from the Internet, several parameters have been reflected against the price in the below table. Some are less interesting; some might be interesting to certain readers. Instead of providing only a few parameters (which ones?), it has been decided to provide as many as possible already obtained parameters, against the price, just for fun ☺

Financial Indicators	Amount in €	In unit
RRP at time of writing	**69.00**	**Euro**
Date of indicated RRP	05-02-2021	dd-mm-yyyy
Price per one U	23.00	Euro/U
Price per one HP	**8.63**	**Euro/HP**
Price per one HPU	**2.88**	**Euro/HPU**
Price per one mm	1.38	Euro/mm
Price per one HPUcm	0.58	Euro/HPUcm
Price per one full HPUcm	0.41	Euro/HPUcm
Price per one gram	0.82	Euro/g
Price per mA for -12 V	3.45	Euro/mA (-12 V)
Price per mA for +5 V	n/a	Euro/mA (+5 V)
Price per mA for +12 V	2.30	Euro/mA (+12 V)
Price per one button	n/a	Euro/button
Price per one contact plate	n/a	Euro/contact plate
Price per one encoder	n/a	Euro/encoder
Price per one knob	69.00	Euro/knob
Price per one pad	n/a	Euro/pad
Price per one slider	n/a	Euro/slider
Price per one switch	69.00	Euro/switch
Price per one CE	34.50	Euro/CE
Price per one input	69.00	Euro/input
Price per one output	13.80	Euro/output
Price per one IO	11.50	Euro/IO
Price per one CE & IO	**8.63**	**Euro/CE & IO**

Table 13 - Financial Indicators

4 User interface experience

Even before one has installed the module or at the very least before one starts to read the manual and even patched the module, one of the first things one usually does is touching a few knobs, how it feels, pull a switch or press a button. This first impression is pretty important and though non-technical, it can provide already a first judgement of the module even before really start using it. This chapter is about that first impression with the focus on the user interface experience.

Please note that many characteristics and parameters have already been discussed in detail in the paragraph 3.7 - Look, touch & feel impressions and will therefore not be repeated here again, unless needed to discuss another aspect of the user interface experience.

4.1 The look & the first impression

This module has a typical, classical Doepfer look, straight forward and to the point. Nothing fancy however it provides the user a good overview of the module and the usage is self-explanatory. The module provides five (5) simultaneous LFO wave type outputs.

4.2 The touch and the quality

This Doepfer module has a good build quality as most Doepfer modules do.

4.3 The user interface experience

The user interface experience is usually good with Doepfer modules. The knobs are sturdy and firm, but not too firm, to turn to get the correct setting easily. The distances between the knobs and control elements in general are usually comfortable with Doepfer modules whereby this module is might be for right-handed persons a slightly bit less comfortable to use than for left-handed persons since the switch is a bit too close under the frequency knob. It is possible, also for right-handed persons, no issues, just a fraction less comfortable then it could have been.

4.4 The patching

Doepfer modules have usually a good reputation if it comes to patching and this module is from a general look at it no exception to that. The IOs are all on the left-hand side, which one might not feel as comfortable as when it would be all at the bottom whereby left-handed persons might easier feel a bit of discomfort when trying to reach the knobs than right-handed persons. Though in case with this LFO module it is not too bad for left-handed persons either since there is only one knob and one switch that's in this case for left-handed persons a bit easier to handle because of the positioning of these CEs.

5 Functionality overview

The main functionality of this Doepfer - A-145-1 module is a LFO. In the next paragraph a very general view on some common functionality will be mentioned. The following paragraph however, the LFO functionality will be specifically displayed in details.

In the paragraph thereafter a rough indicative flow diagram of the module will be provided for a better understanding of where the inputs (if any) flow through the module from a schematic/flow diagram point of view towards the outputs. The author might sometimes refer to this flow diagram, to make matters easier to understand.

To see this module in action, please refer to the (video) links provided in paragraph 3.4 - Other reference links, it's not an extensive list of all available demos however just a few main links known to the author.

For general information about this module like the manual or manufacturer's website and a link to modulargrid.net please refer to the paragraph 3.3 - References.

For a detailed explanation on all parameters and characteristics mentioned in this chapter please refer to paragraph 7.5 - Functionality overview.

5.1 General functionality

In the below table the general functionality of this module has been listed, for more details please refer to paragraph 5.2 - The LFO functionality.

Characteristic	Comment or value
Main function	LFO
Sub function(s)	n/a
Analogue or digital	analogue
Digital sample rate in kHz	n/a
Digital sample depth in bits	n/a
Chainable	no
Designer	n/a
Multiple	single
Bleeding	n/a
Trimmer - calibration	n/a

Table 14 - General functionality

5.2 The LFO functionality

In this paragraph the functionality specifically of the LFO will be discussed for this particular module.

The details specifically for this reviewed module's LFO functionality has been mentioned in the following table.

Characteristic	per CE	per IO	Comment or value
Frequency/rate	1 knob	n/a	~0.005 Hz - 4.5 kHz
Frequency range	1 switch	n/a	high, medium & low
Time range	n/a	n/a	~0.2 ms - 3.5 min.
Morphing	n/a	n/a	
Phase shift	n/a	n/a	

Table 15 - LFO functionality

The frequency range can be set with a 3-position toggle switch with these positions:

High - from about 10 Hz till 4500 Hz (mainly in the audible area)
Medium - from about 0.1 Hz (10 seconds) till 50 Hz (0.02 seconds or 20 ms)
Low - from about 0.005 Hz (3.5 minutes) till 5 Hz (0.2 seconds)

Naturally, one of the key parameters is still missing, which is the type of output waves. The types of output waves have been reflected in the next LFO outputs table.

Wave type	Output	Comment or value
Clocked noise	n/a	
Cosine	n/a	
Envelope	n/a	
Flexible wave	n/a	
Pulse	n/a	
S & H/Stepped triangle	n/a	
Saw	yes	simultaneously
Saw - reversed	yes	simultaneously
Sine	yes	simultaneously
Square	yes	simultaneously
Trapezoid	n/a	
Triangle	yes	simultaneously

Table 16 - LFO outputs

This LFO has simultaneiously 5 wave output types, see details in the above table.

5.3 The subfunction(s)

This particular module has beside the LFO main function no subfunction functionality.

5.4 The flow diagram

In the figure here below, one can find the rough flow diagram of this module. It is not meant to be extremely extensive or till the very last bit accurate diagram however the idea behind it is to provide the reader a quite good idea of how the signals, of this module, are being processed, where CEs come into place and where in the flow diagram the IOs can be found.

Or to summarise this: A pictures says more than one thousand words can explain.

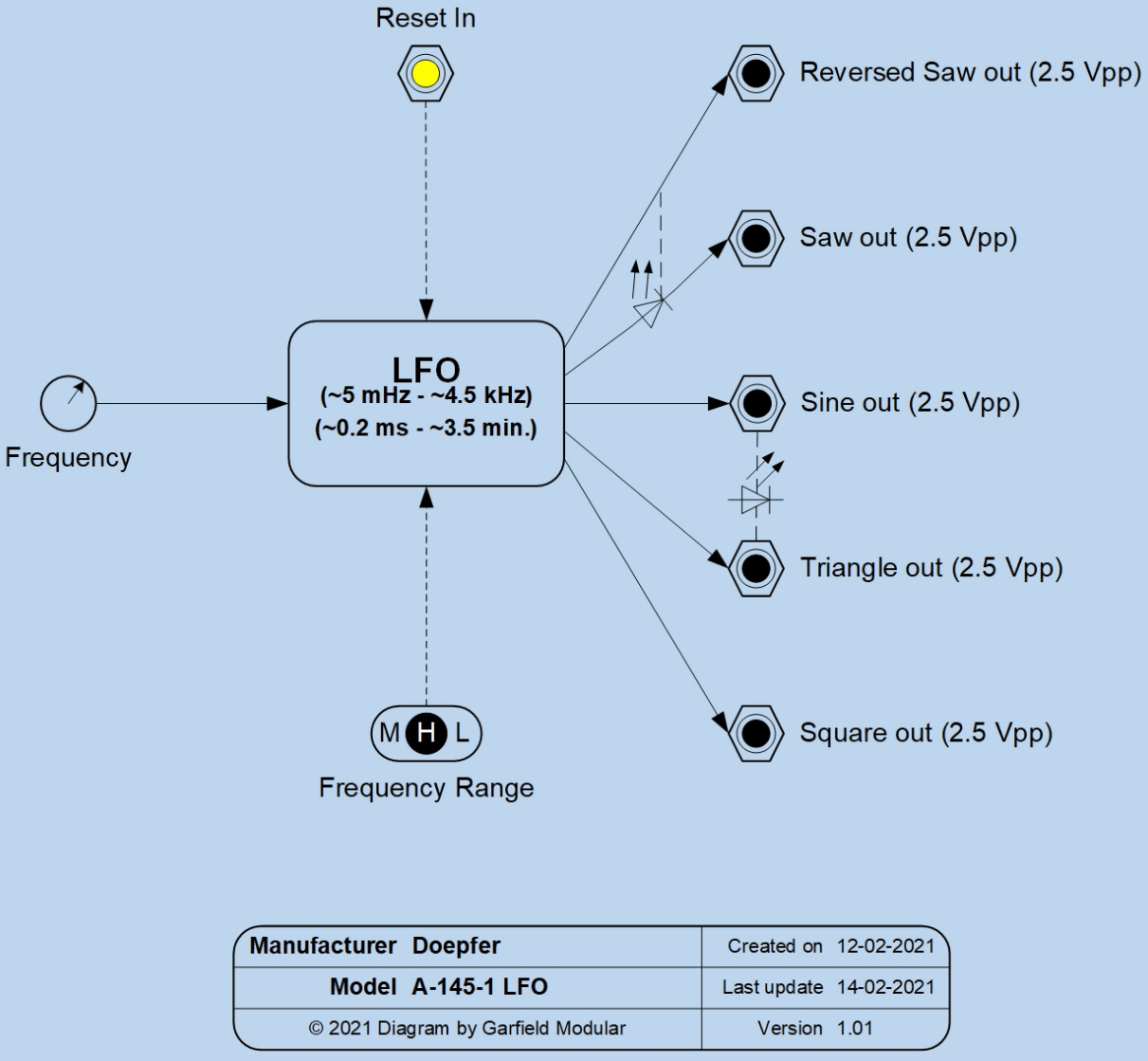


Figure 3 - The flow diagram of Doepfer's A-145-1 LFO module

5.5 Comparing this LFO module with other LFO modules

In this paragraph this LFO will be compared with other LFO‘s to have a look at similarities as well as a few obvious differences.

More modules of the same functionality are required. As soon as there are sufficient review reports ready for this functionality, this paragraph will be extended for future LFO modules.

For the moment this is a placeholder only.

6 Audio & sound experience

For the combination of a video demo with sound, naturally, for example, a YouTube video can be checked out for this module; see paragraph 3.4 - Other reference links.

This chapter is rather about audio, sound, sonic, noise, whatever one would like to call it ☺.

Not unimportant for a module Is how does it sound? The user interface experience has already been discussed as well as the functionality but it’s about time to talk about the sound that this module can produce.

6.1 Main LFO function default sound possibilities

The default or standard main LFO function sound possibilities will be discussed here.

This is an LFO module that doesn't produce sound on its own unless one sets it in high-speed mode then audible frequencies are possible.

For a demo, please refer to this paragraph: 6.3 - Possible interesting sound bits.

6.2 Sub function sound possibilities

This module doesn’t have any sub functions and therefore not applicable for this particular module.

6.3 Possible interesting sound bits

Besides the default or standard sound possibilities, in this paragraph the more interesting “bits” will be mentioned.

To provide at least something for this LFO, using here the same patch and sound demo as for the Doepfer - A124 VCF5 Wasp filter, at least the LFO comes "into action" in that patch. Please refer to below link for that:

https://soundcloud.com/user-962819266/extremes-of-doepfer-a124-wasp-filter-a140-1-adsr-and-a145-lfo

The patch for using here this LFO module has been displayed in the next figure.

A warning here is in place since the above demo sound is not about being musically nice sounding, it's rather quite heavy on being non-musical and might not be for everybody's liking. Its purpose is rather to showcase the capabilities of the Doepfer's three modules: A-124 VCF Wasp Filter (using here high pass only), A-145-1 LFO "in all its glory" meaning low, medium and high speeds, using triangle wave and the A-140-1 ADSR to control the VCA.

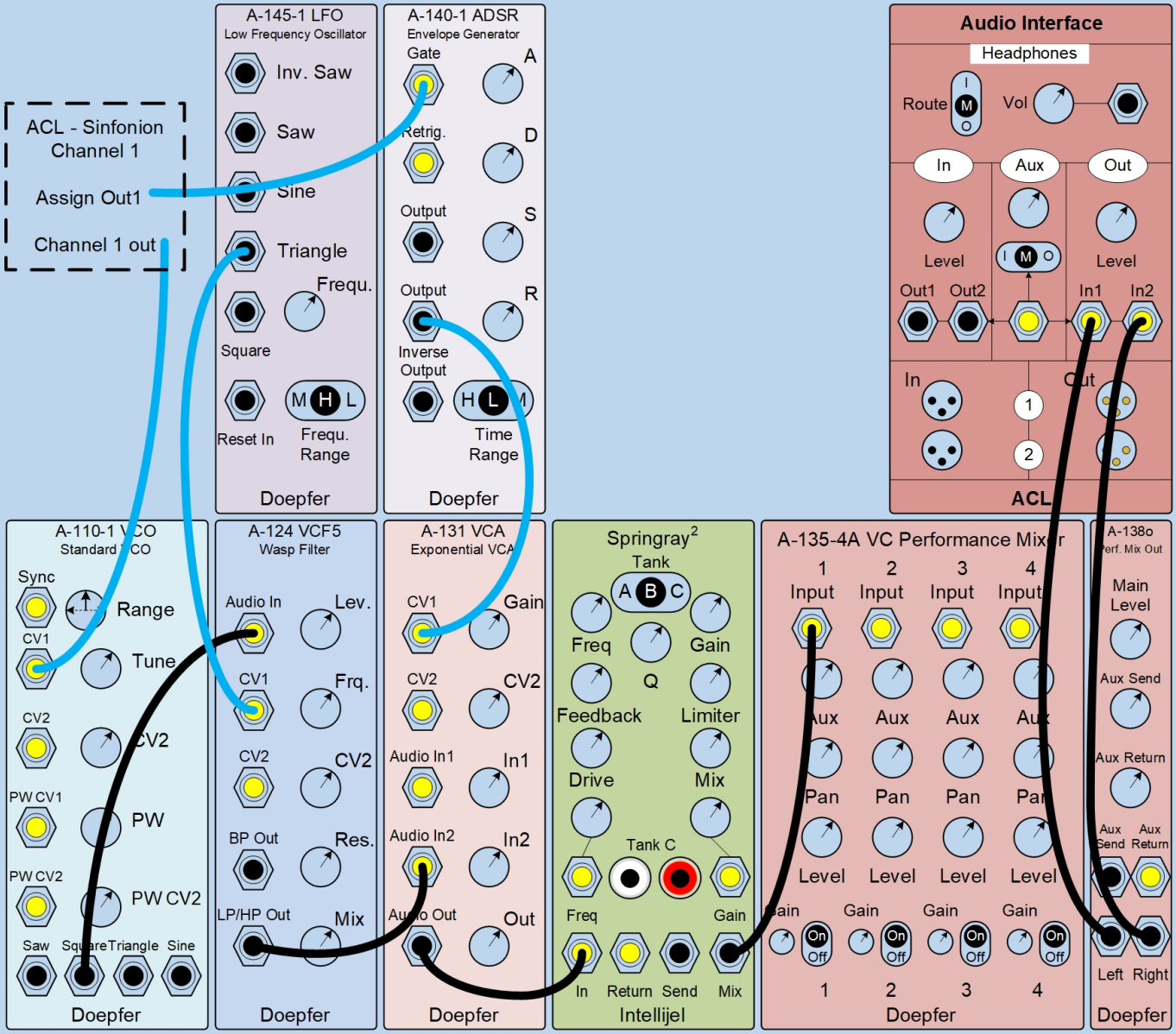


Figure 4 - Patch diagram for Doepfer - A-145-1 LFO, A-140-1 ADSR & A-124 Wasp filter

7 Appendix A – Eurorack module details explanation

The document has been kept brief about explanations what does what means. This appendix is however especially created just for that purpose, keeping the main document clean and tight, whilst, if the reader needs an explanation on what certain parameters or details mean, this can be found here.

To make it easy for the reader to find a parameter from a certain (sub-) paragraph back here in this Appendix, one takes the (sub-) paragraph number of the main document and adds that here behind the appendix chapter number.

An example: One would like to get a better understanding about the paragraph 3.5 - Module measurements the volume characteristic of the module expressed in HPUcm. The only thing to be done here is then add this chapter number 7 of this Appendix A – Eurorack module details explanation in front of that paragraph number 3.5 where that HPUcm has been mentioned, i.e.:

This chapter number: 7
Question about (sub-) paragraph number: 3.5
Thus (sub-) paragraph number here would be: 7.3.5

This above explained “system” causes a few placeholders though, meaning (sub-) paragraphs that don’t require explanation however need to be mentioned here so the above explained system works consequently correct.

This here is Appendix A – version 1.03

That means that if you had read this once and as long as this version number stays the same here for Appendix A then you don’t have to read it again for another Review Report, the idea is that this Appendix stays about the same for all Review Reports and can be recognised at the version number displayed here above.

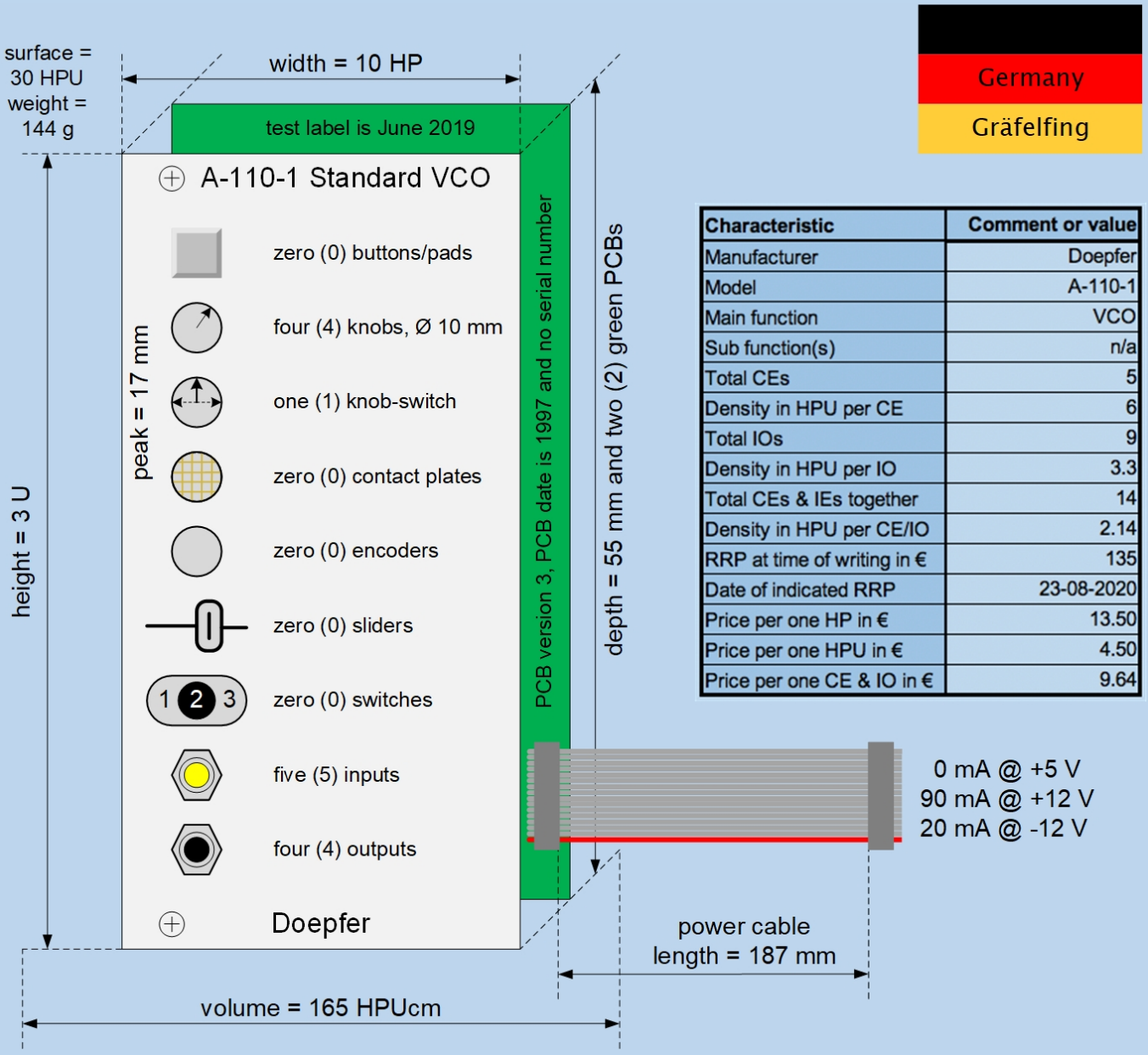
The above assumption is valid for the functionality discussed here, i.e. LFO. If one reads another review report for another module functionality then all is about the same, except chapter 5 - Functionality overview that will be different and depending on the functionality.

7.1 Introduction

This requires no further explanation, here as a placeholder only.

7.2 The module summarised

In the below figure an example of the summarised module has been provided.



Characteristic	Comment or value
Manufacturer	Doepfer
Model	A-110-1
Main function	VCO
Sub function(s)	n/a
Total CEs	5
Density in HPU per CE	6
Total IOs	9
Density in HPU per IO	3.3
Total CEs & IEs together	14
Density in HPU per CE/IO	2.14
RRP at time of writing in €	135
Date of indicated RRP	23-08-2020
Price per one HP in €	13.50
Price per one HPU in €	4.50
Price per one CE & IO in €	9.64

Figure 5 - Example of the module summarised

The above picture reflects a symbolic way of the module (here just an example picture and module, not necessarily reflecting the module discussed in this particular document) in a summarised way, it contains the main data of the module in a graphical overview. For detail definitions and explanations of the parameters please refer to the subparagraphs: 7.3.2 - General module details, 7.3.5 - Module measurements, 7.3.8 - PCB details, 7.3.9 - Power consumption, 7.3.10 - Inputs & Outputs (IOs) and Control Elements (CEs), 7.3.11 - Financial indicators and 7.5.1 - General functionality.

The “above” module with the name (either at the top or at the bottom of the module) and the manufacturer’s name (either at the bottom or at the top of the module) displays the quantities of the CEs and IOs. It roughly shows the position of the screw hole positions as well as the rough type of the screws that are included (if any).

The underlaying “board” (usually green, not always though) reflects the PCB(s) with details if applicable. In the above module for example this is PCB version 3 and the test label is from June 2019.

Clock-wise starting from 11 o’clock position, the surface in HPU and the weight in g(rams) has been provided, followed by the width in HP. On the right the depth and the number of PCBs. The colour has been very roughly and rather symbolically indicated here.

At the right bottom of that “PCB” the power cable connector (if any) has been reflected with the power cable length and the power consumption values per voltage.

At the bottom one can find the “volume” of the module in HPUcm. This is width HP * height U * depth mm / 10 to get HPUcm) or refer to subparagraph 7.3.5 - Module measurements.

The left hand side shows the height of the module in U. Within the module at the left hand side the module peak value has been provided.

The flag in the upper right corner provides a rough symbolic way of the country (if possible written in the flag) of origin of the manufacturer’s HQ (mentioned if possible, in the flag as well).

The table under the flag represents the most common data in conjunction with this figure and the related displayed data here.

7.2.1 Author’s own opinion

If there is a paragraph in this document where the author is not completely neutral than that’s here. This section of the summarise of the module reflects a bit more the author’s own opinion. The author still tries to be reasonable and tries to provide an opinion as much as possible based on facts however also the author’s own experience and feelings will be reflected here a bit.

For readers that don’t appreciate a bit of an own (author’s) touch in it, it’s advised to ignore this paragraph.

First, the pros and cons are provided, as neutral as possible but, naturally, still a bit influenced by the opinion of the author.

In the next example figure one can see the module rated by the author.

It has to be mentioned that the author is rather critical and does not easily provide high ratings, just for the sake of “getting the traffic lights to green” (the reason though to provide green numbers already from 60 till 100 and not for example from 70 till 100). If one looks on the Internet, and it doesn’t matter much about which subject, but one will see that the “ratings” of many matters are usually pretty high, marked in ways like: “Fantastic food” or “Unbelievable good car” or “The best music I ever have heard”, etcetera. Usually that mentioned food is barely eatable, the car doesn’t perform that well at all and the music is utterly rubbish. The author tries to refrain from that and takes this rather seriously and is usually very critical regarding these values.

It still has to be noted that this section of the document is a section where the author’s opinion is obviously the strongest compared against the rest of the document that the author tries to keep it as neutral observed as possible (hence the many tables with the many parameters that are rather values than opinions); with the exception of these chapters 4 - User interface experience and 6 - Audio & sound experience that are, obviously, influenced by the author’s opinion as well.

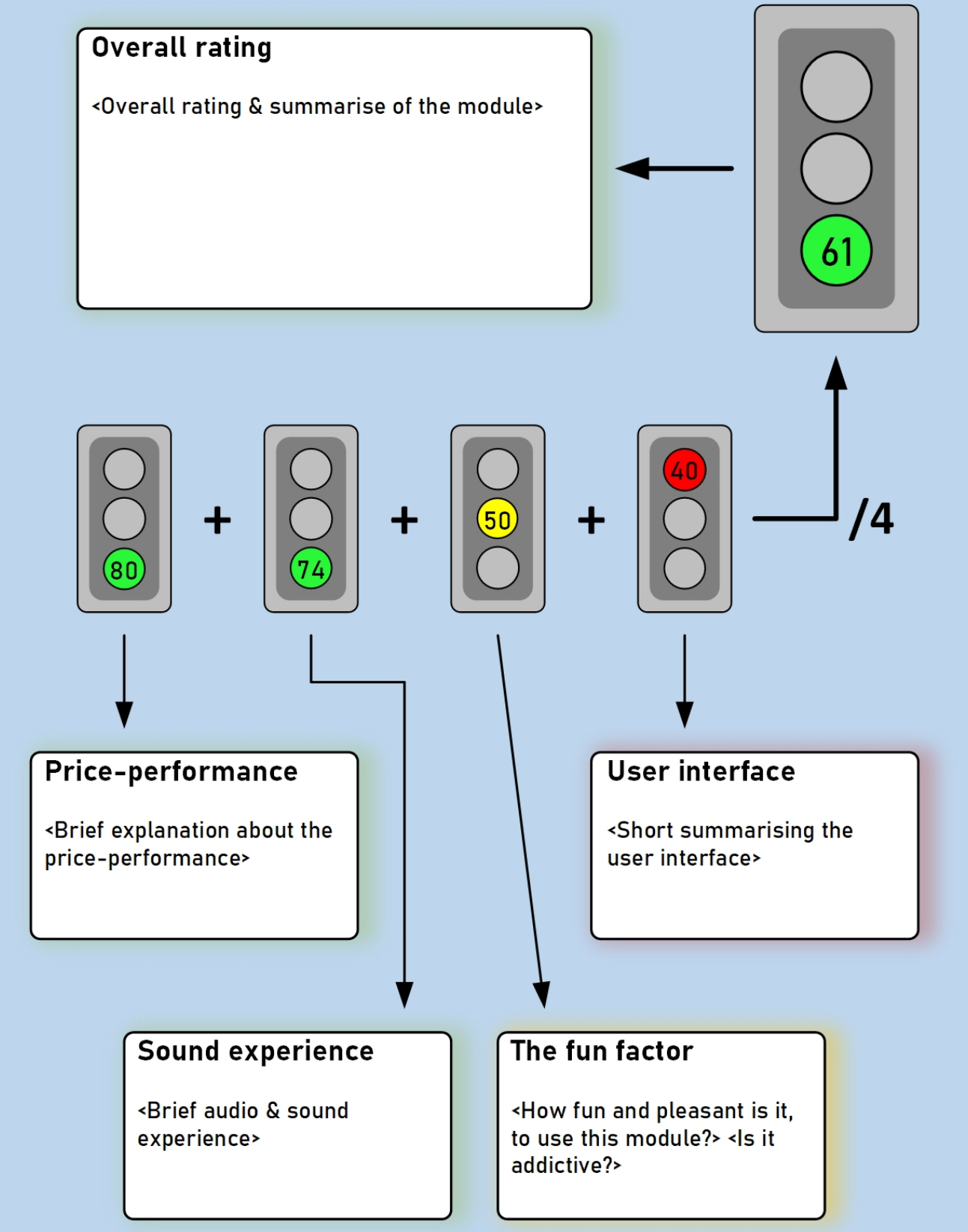


Figure 6 - Example figure of the author's view

At the top of the figure, the large “traffic light” indicates the overall impression (the text on the top left) and rate (the value in the traffic light) of the module. Values between 60 and 100 are indicated in green and considered a good module, values between 40 and 59 in yellow indicate a reasonable good module that could use some improvements and values from 0 till 39 in red are modules, at least that’s the opinion of the author, that are less worth buying them and might have issues worth noting them.

Below the main traffic light there are four (4) smaller “traffic lights” displayed. From the left to the right these indicate the rating values (similar as for the main traffic light) of the following module indicators:

- Price-performance
- User interface
- Sound experience
- The fun factor

The **price-performance** indicates for the price the module costs, is it worth to have this module? The higher the number of this rating the more it is worth to have this module in one’s rack ☺

User interface indicates how good and pleasant is the module in its usage? Are the CEs (and the IOs) too close to each other? Too much menu diving? Then the rating value might be a bit lower. If everything is very good balanced, patch cables all on one side (or at maximum two sides of the module) then most likely the rating number will be higher.

The **sound experience** indicates how impressive sounds the module can generate. Is it after a while that kind of sound that makes one run away from or fall asleep → hence a lower rating value or can exciting sounds be created with this module? Hence a higher rating value.

The fun factor indicates how fun (and pleasant) is it to use this particular module? Does the module invite one to come always back to this particular module, in other words one can’t let it go and “must” use it in almost every patch? If one has tested it a few times and after that barely looks at it any more than the rating value is rather low, however if one every time wants to use this module and one gets the feeling it’s kind of addictive, then yes, the fun factor is likely to be high, hence a (much) higher rating value.

All these four (4) “indicators” are “weighted” equally, meaning that each value in these smaller traffic lights are just counted once per indicator. The sum of these indicators together divided by four (4) provides the overall rating value of this particular module (i.e. that number in that large traffic light).

7.3 Quick overview & facts sheets

Generally speaking, most values, where possible, were taken from the manufacturer's website and/or manual. If there is a difference between these two (and one would be surprised how many times that actually happens!) the "worst" value will be taken. Thus, for the depth of a module the deepest value, for power consumption the highest, etcetera. If no value had been provided by the manufacturer the writer of this document usually takes for:

Module depth in mm will be measured then by the author, very inaccurate (give it at least a 10% till 20% fault tolerance)
The weight of a module (Module weight) is always weighted by the author (regardless if this value has been provided by the manufacturer) since the author includes in this measurement the module plus the power cable. It's measured with a simple digital household scale in grams so give it also a fault tolerance of at least 10%
The length of the power cable (Power cable length) (if any) is in mm and always measured by the author (the author didn't come across a manufacturer who provided this value yet), here the measurement is particular inaccurate and give it at least a fault tolerance of 10% till 20%
Power consumption, the values of some major online shops in Germany and/or the values of modulargrid.net, the author will also try (accent here is on try, so not guaranteed) to contact the manufacturer to get the power consumption values from the manufacturer themselves. If that's successfully, naturally, those values provided by the manufacturer on author's request will then be used and updated (if applicable) at the specific module site at modulargrid.net

All values found by the author on manufacturer's websites, manuals or by self-measurement are pure for indicative purposes and are not to be meant scientifically accurate, it's just that the reader has a rough idea. As well as that for, typos, copy/paste failures, misunderstandings, etcetera that might be involved in the provided information in this document, no rights or whatsoever can be taken from wrong and/or inaccurate provided information.

To summarise: This is for hobby and indicative purposes only ☺

Having all said that, the author still tries to be as accurate as possible, so feedback on typos, copy/paste failures, misinterpretation of data or whatsoever is very welcome and can be provided via the given website (contact webpage) at the bottom of almost each page of this document.

In the below subparagraphs all the parameters and characteristics will be explained in further details.

7.3.1 Document details

The document details are provided in the below example table.

Characteristic	Comment or value	In unit or comment
Date started the review	<date>	dd-mm-yyyy
Date finished the report	<date>	dd-mm-yyyy
Review Report version	**1.00**	
Review Report number	BP_RR_DP_001	
Latest update date	<date>	dd-mm-yyyy
Appendix A version	**1.03**	

Table 17 - An example table for the document details

The day that the author started writing this review report is known as the **date started the review**. Similar for the **date finished the report** that indicates when the review report has been finished.

Review Report version is the version number of this particular review report.

The **Review Report number** starts with BP_ then RR for Review Report followed by 2 (or 3) characters representing the manufacturer and the number thereafter is a unique review report ID number for the mentioned manufacturer.

The review report ID is 3 digits with leading zero by default, in the unlikely case that a manufacturer would have more than one thousand modules and the even more. Unlikely case the author would have written more than 999 documents about those modules then 4 or more digits will be used, without leading zeros though. The chance that this will happen is pretty low though, even Doepfer that has one of the most modules doesn't have 1000 different(!) modules yet…

The **latest update date** is, if applicable, the latest date that an update on this report has been done, this usually results in an increase of the **review report version** too.

Appendix A version indicates the version number of the appendix A, this is or might be a different version number from the review report version and these both are independent from each other. The idea behind this is that once a reader has read the appendix A and as long as that version number stays the same, in other review reports reflecting the same appendix A version number the reader doesn't have to read the appendix A again since that's the same contents. Till the reader sees a difference between the appendix A version numbers and could then decide to read appendix A again (or skip it if it's just a minor version number increase).

7.3.2 General module details

Below an example table of the general module details can be found.

Characteristic	Comment or value
Manufacturer, full name	Doepfer
Manufacturer, short name	Doepfer
Manufacturer, country of origin	Germany
Manufacturer, HQ town	Gräfelfing
Manufacturer, founder(s)	Dieter Döpfer
Module name, full	A-110-1 Standard VCO
Module name, short	A-110-1
Main function	VCO
Sub function(s)	n/a
Version/release	3
In co-operation with	n/a

Table 18 - An example table for the general module details

For document purposes, for the **manufacturer name** as well as for the **module name** a short version as well as the full version has been reflected. Full name would be for example Hikari Instruments, the short name Hikari. The full module name would be Attenuator & Mixer, the short name Atten/Mixer. In the above table example the manufacturer is Doepfer and the module is A-110-2.

Manufacturer, country of origin mentions the country where the manufacturer is located and/or originally comes from together in conjunction with **manufacturer, HQ town** that indicates the town or city where the HQ of this manufacturer has been located.

The **manufacturer, founder(s)** provides the name(s) of the founder(s) of the manufacturer if that's provided either on the manufacturer's website, manual and/or on Wikipedia. If still not found by then other sources for this kind of information might be modulargrid.net or schneidersladen.de website.

Main function speaks for itself, for example the main function can be a VCO, an LFO, a filter, etcetera. **Sub function(s)** are for example if you got the main functionality an EG then the sub function might be an LFO; just as an example here. If there are no subfunctions for that particular module, the full module name might be taken too; or a mixture of both.

Version/release is the main version of the module, if nothing is indicated on the front panel and nothing special on the PCB board as well then this is usually 1 (first version); indeed that is then assumed. The author checks also the PCB board version and sometimes holds that against the main text of some well-known retailer's websites as well as the manufacturer's website. Usually taking the PCB board version as the leading version if nothing else is provided. For details on the PCB board see 7.3.8 - PCB details. If there is more than one PCB with different versions/revisions then the highest version/revision is used here.

The **in co-operation with** shows the name of another manufacturer, company and/or person that might have helped as a third party with the manufacturer of this particular module.

7.3.3 References

At this section references or more accurate website links are provided (where applicable and available). On the left hand side the matter is mentioned and on the right hand side the link (clickable per mouse) has been mentioned.

7.3.4 Other reference links

Similar as with the References here other reference links will be provided. The name of the reviewer or tester has been mentioned and the media location (for example YouTube), it's at the same time a link to that reviewer or tester of this particular module as well.

Here are mainly (but not necessarily only) links provided to (well) known YouTube (or other media sources) modular synthesizer testers/reviewers in alphabetic order. This is not an extensive list of all YouTube movies about the module discussed here but just some of the first few reviews found and listed in YouTube as well as from some kind of "known names".

If serious (YouTube) modular synthesizer testers/reviewers think that their link is missing here just contact the author via the mentioned website at the bottom of this page. One should have then at least ten (10) or more review and/or demo videos of different Eurorack modules that are clearly focussed on the module that's specifically discussed here (and not a bundle of modules taken together and a kind of mixture of modules in one video). It's not necessary to be on YouTube, any other publicly available (video) platform will do as well, as long as it has an acceptable reputation, still kind of well-known and easily available and accessible for readers (i.e. no subscription should be required).

For the moment this will be done at no costs, the author is not sure about the future if this will be a chargeable (most likely a one-time cost then per module review document) feature or if this stays free of charge. Either way, the author would appreciate a reference bi-directional, i.e. here your link is mentioned. In your video or reference, you mention either this module specific report review webpage or the common Garfield Modular website (either per speech/audio or per subtitles, up to you). If you would be so nice to do that, that would be very much appreciated ☺

7.3.5 Module measurements

For this paragraph an example module will be used to explain each of the parameters in the 3.5 - Module measurements paragraph. The values used for this example module are displayed in the below table.

Module measurements	Value	In unit or comment
Module height	3	U
Module width	10	HP
Module depth	55	mm
Module peak	17	mm
Module front plate thickness	2.2	mm
Module (front plate) surface	30	HPU
Module volume	165	HPUcm
Module full volume	222.6	HPUcm
Module weight	144	gram (g)
Module versus packaging	73.1	%
Weight per one mm	2.6	g/mm
Weight per one U	48	g/U
Weight per one HP	14.4	g/HP
Weight per one HPU	4.8	g/HPU
Weight per one HPUcm	0.87	g/HPUcm
Weight per one full HPUcm	0.65	g/HPUcm

Table 19 - An example of module measurements

The module height for Eurorack is by default 3 U. U stands for (Rack) Unit (RU or U), in German HE (Höheneinheit). There are Eurorack modules with 1 U height as well, whereby there are roughly two “standards” for the 1 U, the Intellijel 1 U standard (using standard rails or lipped rails and follows the Eurorack standards-principles) and the Pulp Logic 1 U standard (using non-standard Vector rails or lipless rails following the non-Eurorack standards-principles, i.e. their own standard); for further details please refer to the discussion on Muffwiggler.com website:

https://www.muffwiggler.com/forum/viewtopic.php?f=16&t=154392

For modules that are one U (1 U), if they are Intellijel or Intellijel/Eurorack compatible then “U” will be mentioned or for those 1 U modules that follow the Pulp Logic standard, “U (PL)” will be mentioned to differentiate both “standards”.

The module width is given in HP that stands for Horizontal Pitch or in German TE (which means Teileinheit). One HP is equal to 5.08 mm.

The module depth is calculated most of the times by the manufacturers starting from the backside of the front panel. The depth is in millimetres (mm) and the value will always be measured by the author using simple household tools, i.e. give it at least 10% tolerance. In the measurement, if it’s applicable, the power cable connected to the module will be measured as well since the power cable, usually, peaks out of the PCB. The value might therefore vary from what the manufacturer might provide.

The **module peak** is the module “depth” in the other direction (this terminology has been “invented” by the author), meaning measured from the front panel towards the user in millimetres (mm) however without any patched patch cables. This value will always be measured by the author using simple household tools, i.e. give it at least 10% or 20% tolerance.

In other words, the maximum height that the CEs (and/or IOs) “peak out” from the front panel, hence the module peak value (this terminology has been invented by the author). The next figure shows the difference between module depth and module peak.

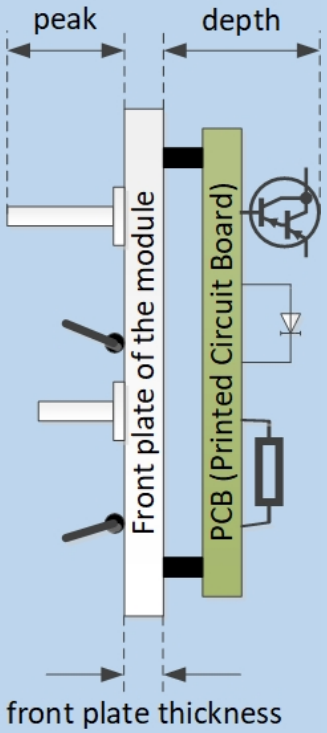


Figure 7 - The difference between module depth and module peak

The **front plate thickness** indicates in millimetres (mm) the thickness of the front plate and has been measured by the author with a simple pair of callipers therefore give the indicated value some room for fault tolerance.

Rather new and “invented” by the author, might be the **module (front plate) surface** in HPU (HP * U), meaning the module front surface calculated as the module width (in HP) times the module height (in U), so a standard 3 U module with 10 HP width from the above example module has a module surface of 10 HP * 3 U = 30 HPU. This can then be used to calculate the IO density and the CE density of a module, see 7.3.10 - Inputs & Outputs (IOs) and Control Elements (CEs).

Module volume in HPUcm (HP * U * cm) takes the module (front) surface in HPU times the module depth in millimetres (mm), assuming here that the module is a perfect box. Naturally in real the front plate is usually a bit larger than the PCB(s) behind the front plate, so the module volume calculation assumes here a perfect box size that is in real life usually not the case. This value is just a calculated value and though this value is not a realistic volume value, it provides a good indication of the volume of the module since the “space behind” the front plate is anyway taken by this module and can’t be used by another module. The volume unit is called HPUcm by the author, meaning the HPU value times the depth value in millimetres (mm) divided by 10 to get centimetres (cm) and to provide a number range similar or rather closer to other values in this measurement table. In millimetres (mm) this number would have been ten times higher.

Compared to the **module volume**, which is the volume behind the front plate of the module, the **module full volume** is the volume behind the front plate, the front plate itself, and the volume “in front” of the module using the module peak value here. The **module full volume** is as following calculated: (depth + thickness + peak) * surface in HPU / 10 in HPUcm.

The module weight is in grams (g) and, as already mentioned previously, it has been measured with a simple digital household scale, use this value for indicative purposes only (estimated fault tolerance somewhere between 10% and 20%?). It has to be noticed that the author measures the weight of the module together with the provided power cable (but no other possible accessories or cables, just the module and the power cable). Naturally in case the module doesn’t require any power, it doesn’t come with a power cable, so it will be measured in such case without the power cable (since it’s not needed and not provided). An example of that could be a passive multiple.

The **module versus packaging** means the ratio in percentage of the module’s weight compared to the original packaging weight (meaning the packaging, module, packing material within that packaging/box, etcetera). The original packaging weight can be found in the subparagraph 7.3.6 - The original box or packaging of the module. In the example of the above table example the module weights 120 gram and the original box weights 240 gram, meaning the module’s weight ratio (compared to the packaging) is 50%.

Weight per one mm means the calculated average weight per one millimetre (mm) of the module depth. From the above table example, a module weight of 144 gram including the power cable measured by the author and a module depth of 55 mm (from, for example, the manual or the manufacturer’s website), then the **weight per one mm** is 144 g / 55 mm = 2.6 g/mm.

Is this a useful value? The author leaves that decision up to the reader, similar for many of the following values.

Weight per one U means the calculated average weight per one U of the module height. From the above table example, a default Eurorack module of 3 U and a module weight of 144 gram, the **weight per one U** is 144 g / 3 U = 48 g/U.

Weight per one HP means the calculated average weight per one HP of the module width. From the above table example, a module of 10 HP and a module weight of 144 gram, the **weight per one HP** is 144 g / 10 HP = 14.4 g/HP.

Weight per one HPU means the calculated average weight per one HPU of the module’s front plate surface. From the above table example, a module with a front plate surface of 30 HPU and a module weight of 144 gram, the **weight per one HPU** is 144 g / 30 HPU = 4.8 g/HPU.

Weight per one HPUcm means the calculated average weight per one HPUcm of the module’s volume. From the above table example, a module with a volume of 165 HPUcm and a module weight of 144 gram, the **weight per one HPUcm** is 144 g / 165 HPUcm = 0.87 g/HPUcm.

Weight per one full HPUcm means the calculated average weight per one HPUcm of the module’s full volume (i.e. calculating here the depth, front plate thickness and the peak; also see module full volume explanation). From the above table example, a module with a full volume of 222.6 HPUcm and a module weight of 144 gram, the **weight per one full HPUcm** is 144 g / 222.6 HPUcm = 0.65 g/HPUcm.

7.3.6 The original box or packaging of the module

For this paragraph an example module will be used to explain each of the parameters in the 3.6 - The original box or packaging of the module paragraph. The values used for this example module are displayed in the below table.

Characteristic	Comment or value	In unit or comment
Original packaging	carton box	
Main colour(s) of packaging	beige-brown	
Inside packaging of the module	bubble wrap	
Original packaging width	168	mm
Original packaging depth	94	mm
Original packaging height	83	mm
Original packaging volume	1310.7	cm^3
Original packaging weight	197	g
Packaging versus module	136.81	%
Number of rack screws	2	
Screw colour	chrome	
Screw type	Philips	
Number of washers	n/a	
Washer colour	n/a	
Number of manual pages	n/a	pages
Power cable included?	yes	
Serial number provided?	no	
Sticker included?	no	
Other items	n/a	

Table 20 - An example of packaging details

The **original packaging** (or box) explains how it looks like, for example like the above example, it's a carton box.

The **main colour(s) of** (the) **packaging** relates to the colours of the original packaging or box in which the module is packed.

With the **inside packaging of the module** is meant how the module is packed in that packaging or box, just without anything or wrapped in paper (like in the above table example) or sealed in plastic, etcetera.

The **original packaging width**, the **original packaging depth** and **original packaging height** are self-measured parameters by the author with a simple basic household tool so a good tolerance should be allowed here, say 10+ %.

The values are in millimetres (mm) and these three values multiplied with each other gives **the volume of the original packaging (original packaging volume)** in which the module is/was packed. To keep that number in reasonable range compared to the other values, this is provided in cube-centimetres instead of in cube-millimetres. In the above table example the volume would be: 200 (width) * 75 (depth) * 60 (height) = 900,000 mm^3 (volume) = 900 cm^3 (volume).

The **original packaging weight** is the total weight how the module arrived in its original packaging/box in grams (g). The **packing versus module** is the package's weight ratio in percentage compared to the module's weight, since the module is always in the packing (at least that should be), this value is always over 100%.

The **number of rack screws** indicates the number of screws that have been included with this module by the manufacturer and the **screw colour** the indicative colour, so if that mentions chrome then it might be or might not be chrome but it looks like chrome; at least to the author it does ☺ Same for gold, if a screw colour is gold then it's very unlikely it's real gold but the colour looks like gold colour, that's how it's meant.

The **screw type** indicates what type of screw it is, for example Philips means a cross screw but not the "real" cross screw that goes over the entire screw but rather the Philips or Frearson way; this is how it should be interpreted. On the Internet there are lovely websites that explains it in all details with nice pictures, however, here it's just meant to be at an indicative level only.

The **number of washers** indicates if there are washers included for this particular module, if yes, then the number of included washers has been provided here.

The **washer colour** is similar to the screw colour for indicative purposes only, for example if it mentioned transparent then that washer might not really be transparent but looks like it's transparent (that kind of milky white kind of transparent, like most white or transparent washers are).

The **number of manual pages** indicates, in case a physical hardcopy of a manual has been provided, the number of pages of such hardcopy manual otherwise n/a will be mentioned.

Power cable included? Indicates if a power cable (typical for Eurorack) has been included, if yes then in the paragraph 7.3.9 - Power consumption one can find the length of the power cable in millimetres (mm). If not than the module is most likely passive, i.e. it doesn't require any electric power.

Serial number provided? If here is mentioned "yes" that means that (usually) on the outside of the original packaging or rather the original box a serial number of the module has been provided. What here is **not** meant is the possible serial number at the back of the front panel or on the PCB → if there is mentioned a serial number then that will be mentioned in the paragraph 7.3.8 - PCB details but not here. Usually though the manufacturers keep these the same, logically ☺

Sticker included? Quite a few manufacturers include a sticker in the original packaging/box together with the module, naturally not all manufacturers do, so here it's indicated if it has been included.

If there are **other items** included anything else included in the original packaging/box beside the module, screws, washers, manual, power cable, serial number and sticker then that's mentioned here; okay beside dust then…

7.3.7 Look, touch & feel impressions

In this section it's about the look, touch & feel experience the user might have when using the module. The below table provides an example.

Characteristic	Value	Comment
Front panel material	aluminium	
Front text colour(s)	black	
Logo colour(s)	black	
Background colour(s)	aluminium	
Number of LEDs and/or lights	n/a	
Brightness	n/a	
Dimmable brightness?	n/a	
Can lights be switched off?	n/a	
Self-illuminating?	n/a	
Screen	n/a	
Usage's directness	direct	
Patch cables' position	left & bottom	

Table 21 - An example table of the look, touch & feel impressions

In this context the **front panel material** is a total guess. Sometimes this information is provided on the manufacturer's website but most of the times it isn't and since the author is no material expert this is a guess only and can be used for indicative purposes only.

The **front text colour(s)**, the **logo colour(s)** as well as the **background colour(s)** are difficult to get that exactly right, so beside that's a good "estimate", it's also the impression of the author. Getting an exact correct description of a colour is very difficult. The reader has to keep in mind that front panels use to change over time, with some manufacturers more often than with others but it happens regularly, so the colours mentioned here are only for the module version that is applicable for this document. Meaning that for other versions of this module, the colours might be different.

Anything that produces light, either being a LED or a "simple" light (bulb) but not vacuum tubes though, are counted for and mentioned here at the **number of LEDs and/or lights** parameter.

The **brightness** characteristic indicates how bright the used LEDs and/or lights are. The **dimmable brightness** indicates and if the LEDs and/or lights can be completely switched off is indicated by **can lights be switched off?** parameter.

The author's own experience is that some modules have LEDs that are close to irritating bright and other modules have nicely dimmed LED lights. The big pity is that the author didn't came across a module yet where the light **brightness** can be dimmed (or increase the **brightness**), that should be a standard option on all modules that produces light as well as a switch off option for lights or so much dimmable that's completely switched off. The author is afraid that most of the times the **dimmable brightness?** parameter will be provided with the "no" value.

On the other hand, **self-illuminating?** indicates if the light of the module is self-illuminating enough to be able to use (perhaps not be able to read all the small text, that might depend strongly on the person's eyes that uses the module) the module in a dark environment, say for example, in a club for live performance. The module needs to be self-illuminating in this matter and "neighbour" lights from other modules can't be considered here. Sometimes difficult to test however the author will try/test this as good as possible within the available possibilities.

Some modules come with a **screen** and in such cases the rough size (usually in words, sometimes in pixels if that has been provided by the manufacturer) will be indicated. If the information is available it will mention for example LCD or OLED, if the author is not sure then just "yes" or "small screen", etcetera.

Usage's directness (or as many people might know this as "menu diving") indicates if the module has "direct usage" meaning that there is no menu (diving), every button or switch has a direct purpose or in case of menu diving how many levels of diving that goes.

The **patch cables' position** clarifies where at the module the patch cables go, for example: all on the right or all at the top or either bottom or top or either left or right, etcetera.

7.3.7.1 Look, touch & feel impressions of the CEs

The main control elements (CEs) have been put here in two tables to provide a quick overview of characteristics of the CEs. Not all parameters are applicable for all CEs, for those that aren't applicable "n/a" (not applicable) will be shown.

Usually only one table is required because when does a module really have more than four (4) different CEs? That will be very rarely the case.

Characteristic / CE type	Button	Encoder	Knob	Switch
Diameter or length in mm	10	10	10	small
Positions or values	2	n/a	n/a	2
Colour(s)	milky transparent	black	grey	chrome
Value indicator colour	n/a	n/a	black	n/a
Push-able?	yes	yes	n/a	n/a
Usage	sturdy press/click	smooth	comfortable	solid switch over
Accessibility	narrow but ok	good	ok	good
Other characteristics	n/a	n/a	n/a	n/a

Table 22 - An example table of several CE characteristics – part 1

Characteristic / CE type	Contact plate	Pad	Slider
Diameter or length in mm	22 * 34	20 * 20	26
Positions or values	n/a	n/a	n/a
Colour(s)	copper	white	black
Value indicator colour	n/a	n/a	green & yellow
Push-able?	touchable	yes	n/a
Usage	pressure sensitive	hard press	smooth hard
Accessibility	acceptable	good	bit narrow
Other characteristics	n/a	n/a	slider with LED

Table 23 - An example table of several CE characteristics – part 2

The diameter or length in mm is a value measured by the author with a simple household tool therefore allow the values a fault tolerance of at least 20% or more. Diameters are usually applicable for buttons, encoders or knobs. Length for sliders and the lever or toggle length for the toggle switches (here it's particularly difficult to measure that accurately, so hence a high(-er) fault tolerance) and size for pads (usually a pad is a square).

For slide switches, for example switches that have rather a slider than a toggle that need to be moved into another position, there the total switch-movement-length of all positions will be measured (from a front panel point of view, not the complete slide switch mounted at the back on the PCB). This might sound a bit confusing therefore the below figure (from a front panel point of view) tries to clarify that.

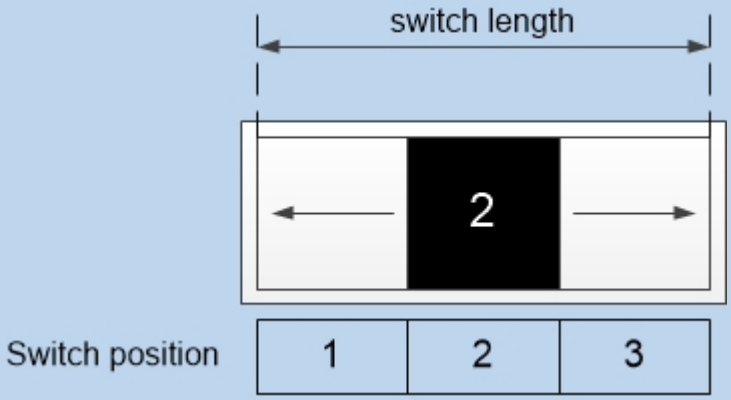


Figure 8 - Switch length of a slide switch

The **positions or values** refers either to buttons or switches, for example the switch positions could have 3 positions: left, middle & right (in the above figure: 1, 2 & 3).

Colour(s) refer to the colour(s) of the CE the part that is pressed, hold or generally hold to "control it" whereby here applies the same, if copper or gold is mentioned then the colour of such CE just looks like copper or gold, it doesn't mean it's really made of copper or gold; i.e. for indicative purposes only regarding the colour (not the used material).

Value indicator colour means, for example on a knob, the indicator that indicates the value, the colour of that indicator. Let's take a classic example here, the Doepfer knobs are usually light grey and have black indicators printed on their knobs.

Push-able? Means if, for example, an encoder is push-able, i.e. can it be pushed down like a kind of button. Most encoders can but there are encoders or perhaps rather knobs that can't be pushed down though have endless turning, for this report review this is still considered as an encoder (and not a knob). Knobs have a begin and an end position and possibly anything between those beginning and ending positions but can't be turned endlessly hence then it's an encoder.

With **usage** is meant how the user experience is during the usage of such CE. This is a bit of an own opinion, though the author tries to observe this as neutral as possible, it can't be avoided to have a bit of an own opinion to this. For example, a slider, how to define this moves smooth or hard or soft? Though a slider might be a bit hard to push it can be still smooth though, so rather calling that then "smooth hard" like in the above example. So… what is hard, what is smooth? Almost unavoidable these kinds of observations will have a bit of an own note into it. At the risk of repeating, the author **tries** to be as neutral as possible.

Accessibility of the CEs has similar difficulties to observe with being neutral and not trying to involve an own note of it into it. If there are two knobs ten centimetres away from each other one can be pretty sure that almost everyone is comfortable with that regarding accessibility. The issue here is, cases like that are seldom so clear and obvious as in this given "example". When do switches and knobs and thus CEs in general get too close to each other that it doesn't become comfortable any longer or even start to work irritating? That's for everybody different therefore being here neutral is very difficult, still the author tries to be neutral and not putting too much of the author's touch in the observations here or in case it is, the author will mention that.

Other characteristics provides an extra comment field in the table for any other characteristics or comments that might be important for the CE that is concerned.

7.3.8 PCB details

PCB stands for Printed Circuit Board and is that (usually) green board with those electronic components on it that's "hidden" behind the front panel of the module. In this paragraph the focus is just on this PCB. Sometimes there are more **PCBs** as well, then this parameter isn't one (1, as it is most of the times) but 2 or 3, etcetera.

Characteristic	Comment or value	In unit or comment
Number of PCBs	2	1 small & 1 big
PCB colour	green	
PCB version	3	version
PCB model/type/others	n/a	
PCB date	1997	yyyy
Test label date	201906	yyyymm
Serial number provided?	no	
Number of vacuum tubes	n/a	
Based on technology	n/a	
µSD card position	n/a	
µSD card capacity, if provided	n/a	GB

Table 24 - An example table of PCB details

The **PCB colour** is, as already mentioned, most of the times green but not always, the (rough) colour indication is given here.

Not always (then "not mentioned" will be mentioned) but sometimes on the PCB there is a version number mentioned, that's in this document called the **PCB version**. If on the front plate no version is mentioned (which is most of the times the case) then the PCB version will be used in this document as the **Version/release** as well in the section 7.3.2 - General module details. It should be noted that some manufacturers call it revision (rev) instead of version, for this review report, version and revision is considered the same.

The **PCB model/type/others** indicates if anything else on the PCB has been mentioned that's worth mentioning it in the review report. Just an example is Make Noise, not on all of their PCBs, however on many of them they display a kind of model or type number, that looks like mn-01-032 (Wogglebug Mk 2) for example. That kind of information might be provided here otherwise just "n/a".

Sometimes on the back of the front panel or more usual somewhere on the PCB a **test label** has been put indicating the date when the module was tested by the test department or production team, depending on the manufacturer's setup. If there is such test label and it mentions a date then that's mentioned here at this parameter otherwise just "n/a". Since the author doesn't work for any of the manufacturers this test label (as it is called here in this document) might be easily misinterpreted and might perhaps not even be a date… the reader of this document should keep this in mind.

Serial number provided? Means that if there is one it's usually mentioned on a label on the PCB, sometimes instead of on the PCB it's on the back of the front panel. This parameter should not be confused with the one mentioned on the original packaging/box, see 7.3.6 - The original box or packaging of the module, yes, it definitely should be the same but that's not what is meant here. Some manufacturers provide the serial number on the outside packaging/box as well as on the PCB.

Waldorf is a bit of a weird exception here, not always but the author has seen modules of Waldorf that have two different serial numbers mentioned on the PCB (by using labels). The author has no explanation for that (yet).

Number of vacuum tubes indicates if vacuum tubes are used and if yes how many.

Based on technology is a characteristic that mentions "n/a" if the author couldn't find information from the manufacturer (hence their website or the manual) about the technology that has been used. This "technology" is a very broad word used here and should be taken lightly. In case information has been provided by the manufacturer (and the author understands it and be able to summarise that here in this small text field) then that will be specified here. For example, if a CEM3340 chip is used for a VCO then "CEM3340" will be mentioned here (the Doepfer – A-111-4 does use the CEM3340 for example).

If the module's PCB has a µSD card slot reader then that's indicated by mentioning if the **µSD card position** is at the front panel or at the PCB backside of the module otherwise n/a will be mentioned if there is no µSD card slot reader. In case the manufacturer includes a µSD card as well the **µSD card capacity, if provided** parameter indicates the capacity in GB of that card (it does not reflect the possible contents on that card).

7.3.9 Power consumption

Below, an example table has been provided.

Characteristic	Comment or value	In unit or comment
Power cable length	187	mm
Power cable type	16	pole wire
Power consumption at -12 V	20	mA
Power consumption at +5 V	n/a	mA
Power consumption at +12 V	90	mA

Table 25 - An example table of power consumption details

The **power cable length** in millimetres (mm) will be measured by the author using a very simple and inaccurate household tool for that, as usual for indicative purposes only. The length is mentioned from where the cable “ends” at the power connector to the other power connector to the point where the cable ends up at that second power connector. The below figure clarifies this a bit better, the “length (in mm)” in the figure is what is meant with the power cable length.

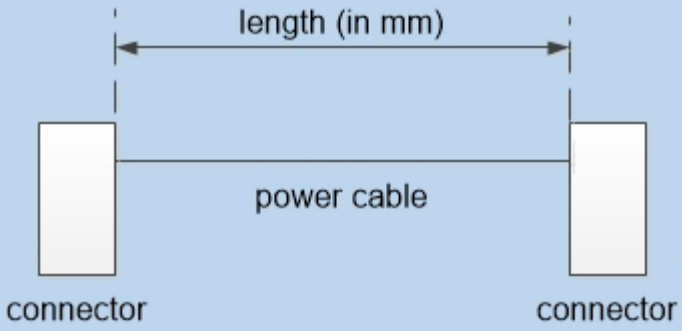


Figure 9 - Power cable length

The figure displays the both connectors and the power cable from a side view.

The **power cable type** indicates if the cable is a 10 pole wire cable or a 16 pole wire cable.

The **power consumption at -12 V** indicates the power consumption in milli-Ampère (mA) for the module in case it uses the -12 V connection.

The **power consumption at +5 V** indicates the power consumption in milli-Ampère (mA) for the module in case it uses the +5 V connection, which is rarely used nowadays.

The **power consumption at +12 V** indicates the power consumption in milli-Ampère (mA) for the module in case it uses the +12 V connection.

7.3.9.1 Power Consumption Indicators (PCIs)

An example table for power consumption indicators (PCIs) can be found below.

PCI	Value	In unit
for -12 V, per gram (weight)	139	µA/g
for +5 V, per gram (weight)	n/a	µA/g
for +12 V, per gram (weight)	625	µA/g
for -12 V, per HP (width)	2	mA/HP
for +5 V, per HP (width)	n/a	mA/HP
for +12 V, per HP (width)	9	mA/HP
for -12 V, per CE	4	mA/CE
for +5 V, per CE	n/a	mA/CE
for +12 V, per CE	18	mA/CE
for -12 V, per IO	2.22	mA/IO
for +5 V, per IO	n/a	mA/IO
for +12 V, per IO	10	mA/IO
for -12 V, per CE & IO	1.43	mA/CE & IO
for +5 V, per CE & IO	n/a	mA/CE & IO
for +12 V, per CE & IO	6.43	mA/CE & IO

Table 26 - An example table for power consumption indicators (PCIs)

The **for -12 V, +5 V or +12 V, per gram (weight)** PCI provides the average calculated power consumption in µA (in mA the value would have been in most cases too low) per one gram.

The **for -12 V, +5 V or +12 V, per HP (width)** PCI provides the average calculated power consumption in mA per one HP.

The **for -12 V, +5 V or +12 V, per CE** indicator PCI the average calculated power consumption in mA per one CE (Control Element).

The **for -12 V, +5 V or +12 V, per IO** PCI provides the average calculated power consumption in mA per one IO (Input or Output).

The **for -12 V, +5 V or +12 V, per CE & IO** PCI provides the average calculated power consumption in mA per one CE & IO from the total CEs & IOs together.

For further explanation of CEs and IOs please refer to the 7.3.10 - Inputs & Outputs (IOs) and Control Elements (CEs) subparagraph.

7.3.10 Inputs & Outputs (IOs) and Control Elements (CEs)

This paragraph focusses on the input and output connections (IOs) as well as on the control elements (CEs), meaning a switch, button, knob, etcetera.

Each parameter provides the number of that what the parameter indicates. If such parameter indication doesn't exist (value is zero) or is not applicable then "n/a" will be mentioned instead.

7.3.10.1 Inputs & Outputs (IOs)

All the parameters of the below table will be explained in this subparagraph.

Inputs & Outputs (IOs)	Inputs	Outputs	Comment
Audio	n/a	4	mini-jacks
CV	4	n/a	mini-jacks
Clock	n/a	n/a	mini-jacks
Gate	n/a	n/a	mini-jacks
Reset/sync	1	n/a	mini-jacks
Trigger	n/a	n/a	mini-jacks
Others	n/a	n/a	
Jack 6.35 mm	n/a	n/a	
MIDI	n/a	n/a	
RJ-45 (Ethernet)	n/a	n/a	
USB	n/a	n/a	
XLR	n/a	n/a	
Total IOs	**5**	**4**	n/a

Table 27 - An example table of the Inputs & Outputs (IOs) overview

On the left hand side, the **Inputs & Outputs (IOs) types** are mentioned and is followed by three (3). The 2nd column represents the **inputs**, the 3rd column the **outputs** and the last column the possible **comment**(s).

The first six (6) rows (Audio, CV, Clock, Gate, Reset/sync and Trigger) are inputs and outputs based on mini-jacks 3.5 mm only. As from the row starting with "Others" it can be either for a mini-jack 3.5 mm or another type of connector/plug.

Examples of how to read this table using the above example table: In the column "Outputs" directly the first row shows number "4" indicates that this specific module has 4 audio outputs (3.5 mm).

Or in the column "Inputs" the second value is "4" and indicates that this specific module has four CV input mini-jacks.

Last example, in the "Inputs" column the 8th value is "n/a" means that there are no jack 6.35 mm input connectors for this specific module, etcetera.

The last row **total IOs** indicates the totals per column, one for the inputs and one for the outputs.

Below all the IOs will be explained one by one:

The **audio** parameter mentions the number of audio input or output (depending on the column) signals.

The **CV** parameter mentions the number of inputs or outputs that function (or supposed to function ☺) as a CV signal.

The **clock** parameter mentions the number of inputs or outputs that function as a clock signal.

The **gate** parameter mentions the number of inputs or outputs that function as a gate signal.

The **reset/sync** parameter mentions the number of inputs or outputs that function as a reset or sync (hard or soft sync) signal.

The **trigger** parameter mentions the number of inputs or outputs that function as a trigger or retrigger signal.

The **others** parameter mentions the number of inputs or outputs that function as another type of signal or connection.

The **jack 6.35 mm** parameter mentions the number of inputs or outputs that uses a jack (6.35 mm) connection.

The **MIDI** parameter mentions the number of MIDI input or output connections; meaning the typical MIDI DIN connection.

The **RJ-45 (Ethernet)** parameter mentions the number of RJ-45 input connections. It has to be noted that RJ-45 connections are usually bidirectional and therefore shouldn't be counted double here in the input column and in the output column. If there is only one (1) RJ-45 then it will be counted as an input (even though if it has output functionality as well), if there are two (2) then one will be counted for in the input column and the other one as an output, etcetera for more connections (odd as with 1 and even as with 2). Strictly speaking it's not an RJ-45 connector but an 8P8C connector, however the author uses in this document the terminology RJ-45 when meaning an (Ethernet) network connection using the RJ-45 or actually the 8P8C connector.

The **USB** parameter mentions the number of USB input connections. It has to be noted that USB connections can be bidirectional, as well as unidirectional and therefore shouldn't be counted double here in the input column and in the output column in case it is indeed bi-directional. If there is only one (1) USB connector then it will be counted as an input (even though if it might has output functionality as well), if there are two (2) then one will be counted for in the input column and the other one as an output, etcetera for more connections (odd as with 1 and even as with 2). Of course, if there is only one USB that is indeed an output only then that will be mentioned as an output only connection.

The **XLR** parameter mentions the number of XLR input or output connections.

7.3.10.2 Control Elements (CEs)

With control elements (CEs) are meant buttons, switches, sliders, knobs, encoders, pads, contact plates, anything that provides you a control “over the module” so to speak, using here the name “control elements” to describe such “elements” or “things”.

“Buttons” or whatsoever on touch screens are not considered for the control elements here.

The below table provides an example.

Control Elements (CEs)	Number of CEs
Buttons	n/a
Contact plates	n/a
Encoders	n/a
Knobs	4
Knob-switches	1
Pads	n/a
Sliders	n/a
Switches	n/a
Total CEs	**5**

Table 28 - An example table of CEs overview

Buttons means the number of buttons available on this particular module. With button or push button is meant something that can be pressed down (even if it has a switch functionality behind it) with the exception of pads and encoders.

Contact plates means a contact or something that usually can be activated by pressing it by a finger (or perhaps by a toe? ☺). Modules with contact plates are for example: Make Noise – Pressure Points, Make Noise – Teleplexer, Mutable Instruments – Ears, etcetera.

Encoders means the number of encoders available on this particular module. Encoder here means a knob that can be turned around without a beginning and an ending position, not necessary with a pressing function though like the Bizmuth (even if that might be the official meaning of an encoder).

Knobs means the number of knobs available on this particular module. A knob that has a beginning and an ending position but can be pressed is considered to be an encoder and wouldn’t be counted for here but rather at the number of encoders. A knob that works as a switch, please refer to knob-switches.

Knob-switches are the number of knobs that actually are switches. For example, a knob that can be turned around and has for example only four defined fixed positions: 1, 2, 3 and 4.

Pads means the number of pads available on this particular module whereby a pad is in a way a button as well however rather being a pad of not selecting or deselecting a function or something like that but instead of that more like selecting for example a tone. A module with pads is for example the Endorphin.es – Ground Control.

Sliders means the number of sliders available on this particular module. Modules with sliders are for example: Hikari Instruments – Atten/Mixer, Hikari Instruments – Triple AD, Intellijel – Metropolis, Malekko – Manther Growl, Malekko – Quad Envelope, Malekko – Quad LFO, Malekko – Varigate 4+ & 8+, Malekko – Voltage Block, Mutable Instruments – Stages, etcetera.

Careful with the Intellijel – Metropolis, the upper row are 8 sliders then below it, those two rows of 8 are not sliders but slide switches ☺

Switches means the number of switches available on this particular module. A switch is either as the here above mentioned with the Intellijel – Metropolis, i.e. a slide switch or usually it's a toggle switch that has a toggle that needs to be pulled over to another switch position. I.e. a (push) button being pressed to switch to another functionality is not considered a switch; at least not for this review report. With a switch is really meant the physical thing that needs to be switched into another position.

Total CEs is the total of all the above-mentioned CEs together of the entire module.

7.3.10.3 Total overview of CEs, IOs and densities

The totals of CEs and IOs are provided here as well as the densities in the below example table.

Totals & Densities	Total	Density in HPU per CE and/or IO
Total CEs	5	6
Total inputs	5	6
Total outputs	4	7.5
Total IOs	9	3.3
CEs & IOs together	**14**	**2.14**

Table 29 - An example table of CE & IO totals and densities

In the table on the left-hand side are the main parameters provided in the column called **Totals & Densities**. In the middle column the **total** is mentioned for each of the main parameters and in the last column the **densities in HPU per CE and/or IO** for each of the main parameters.

Total CEs are the sum of all the CEs mentioned in the previous subparagraph 7.3.10.2 - Control Elements (CEs). The **total CEs** density in HPU per CE indicates how dense the module is filled up with CEs. Taking the example tables values then in that example with a module with of 10 HP, the module surface is 30 HPU. From the above example table taking the total CEs of 5, then the CE density is 30 HPU / 5 CEs = 6 HPU per one control element (CE). This means, each CE (control element) uses a “module front plate space” of 6 HPU on average.

In other words, the lower this number the higher the CE density is. This might be in indicator for the user experience of a module. On one hand it’s good to have a large number of CEs to have more control over the functions of a module on the other hand if the density gets too extreme it might be not too practical to have to struggle with the fingers between all those control elements finding the way to the right CE. Naturally this is influenced by the taste and experience from the author’s point of view. Here, just the number has been provided nothing else, i.e. not the possible interpretation of it.

Total inputs parameter is the sum of all input sockets for this module taken from 7.3.10.1 - Inputs & Outputs (IOs) subparagraph. In other words, the Total IOs of the IOs overview table, the “Input mini-jacks 3.5 mm” total plus the “Other inputs” total.

The **total inputs** density value in the next column indicates how dense the module is filled up with input sockets. The given value there is the number of HPU per input socket.

Total outputs parameter is the sum of all output sockets for this module taken from 7.3.10.1 - Inputs & Outputs (IOs) subparagraph. In other words, the Total IOs of the IOs overview table, the “output mini-jacks 3.5 mm” total plus the “Other outputs” total.

The **total outputs** density value in the next column indicates how dense the module is filled up with input sockets. The given value there is the number of HPU per input socket.

Total IOs are the both Total inputs and Total outputs added together.

The **Total IOs** density in HPU per IO indicates how dense the module is filled up with IOs. Taking the example of a module width of 10 HP again, 30 HPU module surface with a standard size 3 U module, with the totals from the above example table: 5 inputs and 4 outputs, looking at a total of 9 IOs, the density is then 30 / 9 = 3.3 HPU per IO. Compared to the above example of 6 HPU per CE, the number 6 is higher than 3.3 thus a higher density of IO in this example then the above example with the CE → because the lower the number, the higher the density.

But what does that tell the reader? Just looking at it pure from a number perspective it just says that for every IO, 3.3 HPU module surface has been used (please note, this 3.3 HPU is an average). Nothing more, nothing less.

One could understand (could not must) from the IO density that the higher the density gets the higher the chance is that there are quite some patching possibilities with the particular module. Naturally one number doesn't say much and everything has to be seen and checked within the context of the rest of the module and its parameters.

CEs & IOs together is the total number of control elements (CEs) and inputs & outputs (IOs) together. In the above table example this is 5 CEs + 9 IOs = 14 **CEs & IOs together**.

The **CEs & IOs together** density in HPU per CE+IO means the density of the **total CEs & IOs together** compared to the module surface, again, the smaller the number in HPU, the higher the density is. Taking the above example of the total CEs & IOs together as 14 and the module surface of 30 HPU, the entire density in HPU per CE+IO is then 30 / 14 = 2.14 HPU per CE or IO.

Putting this differently, for every CE or IO, each of the CE or IO uses 2.14 HPU "module surface" space on the module. Please keep in mind that this is an average number, some CEs might be clustered quite close together for a good purpose while putting it a bit away from a bundle of IOs, so that number 2.14 HPU doesn't say much because it's an average.

The practical meaning of this could (not must) mean that the lower this number is (meaning higher density) the more functionality (CEs) there might be or the more patching opportunities (IOs) there might be possible for that particular module. A too low number (too high density) could mean (not must) that it becomes practically more difficult to reach everything if everything is fully patched with cables, hence the user experience might start to decrease if it's too dense.

One can't and shouldn't take easily conclusions from this, so many other factors play a role, like the function of the module. For a multiple it's okay to have a higher density than for example a VCO. On the other hand, a large module being a VCO with a very low density could indicate (but not necessarily) that the functionality and/or patching possibilities are less good.

It's however very difficult to put realistic examples and number ranges, to say for example between that and that range it's okay but between that and that range it's not. That would be too extreme comparing without taking the rest of the parameters into account of the module.

It can be however used if one build's up experience, for oneself, with these parameters. Everyone has a different taste and feeling with certain things, the same here, so one can use these numbers as a kind of own reference after some experience with comparing to other modules and then decide what is and what isn't (the above explained parameters and their values) so acceptable for certain modules.

The author just provided a few examples of how it **could** be interpreted however wants to leave this completely up to the reader as in how to really interpret (or just ignore) the values of the parameters of the module. The author wants to stay here as neutral as possible without impregnating an own opinion.

7.3.11 Financial indicators

The below table provides an example table of the financial indicators.

Financial Indicators	Amount in €	In unit
RRP at time of writing	**135.00**	**Euro**
Date of indicated RRP	23-08-2020	dd-mm-yyyy
Price per one U	45.00	Euro/U
Price per one HP	**13.50**	**Euro/HP**
Price per one HPU	**4.50**	**Euro/HPU**
Price per one mm	2.45	Euro/mm
Price per one HPUcm	0.82	Euro/HPUcm
Price per one full HPUcm	0.61	Euro/HPUcm
Price per one gram	0.94	Euro/g
Price per mA for -12 V	6.75	Euro/mA (-12 V)
Price per mA for +5 V	n/a	Euro/mA (+5 V)
Price per mA for +12 V	1.50	Euro/mA (+12 V)
Price per one button	n/a	Euro/button
Price per one contact plate	n/a	Euro/contact plate
Price per one encoder	n/a	Euro/encoder
Price per one knob	33.75	Euro/knob
Price per one pad	n/a	Euro/pad
Price per one slider	n/a	Euro/slider
Price per one switch	n/a	Euro/switch
Price per one CE	27.00	Euro/CE
Price per one input	27.00	Euro/input
Price per one output	33.75	Euro/output
Price per one IO	15.00	Euro/IO
Price per one CE & IO	**9.64**	**Euro/CE & IO**

Table 30 - An example table of financial indicators

RRP at time of writing is in Euros. RRP stands for Recommended Retail Price or in German it's usually called UVP (Unverbindlicher Verkaufpreis). It's here for this document not so important to be 100% accurate on this definition of RRP or UVP, here for this document it is meant that the author of this document takes a few major (online music shops that have a good selection of modular synthesizer modules in their catalogue) and uses the most common price of the particular module. So perhaps it's better to consider this RRP more like a market price instead (at the moment of checking, that's why the date has been provided).

Since the author lives in Germany, this will be oriented towards the German market and indicative prices though for some brands unavailable in Germany, shops in other European countries have been checked to obtain a price. Generally speaking, the author checked other (European) country's prices and they are very similar to the German prices, so the indicated price should work out at least in Europe as a good indicative value.

For Northern American readers, sorry that no American Dollar prices have been provided, since the exchange rate keeps changing it would be too much efforts to indicate US$ and other currency prices too. The author is quite confident though to assume that for North America the price in Euro can be changed into US$. It might not be always accurate however for indicative purposes this is a not too bad work around either.

For other users the author apologises for the inconvenient of only providing Euro prices, it would have been however extending the scope and efforts by far too much for the author, therefore it has been decided to stick with Euro prices only. They are anyway for indicative purposes only and perhaps in another currency a better deal can be found ☺.

The **Date of indicated RRP** indicates on which date the RRP has been checked/retrieved.

Price per one U means the calculated average price per one U of the module height.

Price per one HP means the calculated average price per HPU of the module width. For the example in the above example table and the same module for the other paragraphs using that 10 HP module, the average price per one HP is Euro 135 RRP / 10 HP = 13.50 Euro per HP.

Is this a useful parameter? That's up to the reader to decide, since all parameters were available anyway, the author decided to display them all here. Up to the reader to decide which one is useful and which one isn't or perhaps all aren't… For the author this is mainly a fun table with fun values but one or two could actually even make a slightly bit sense not much indeed but as a very rough indicator perhaps.

Price per one HPU means the calculated average price per one HPU of the module (front plate) surface.

Price per one mm means the calculated average price per one mm (millimetre) of the module depth.

Price per one HPUcm means the calculated average price per one HPUcm of the module volume.

Price per one full HPUcm means the calculated average price per one HPUcm of the module full volume.

Price per one gram means the calculated average price per one gram of the module weight.

Price per mA for -12 V, **price per mA for +5 V** and **price per mA for +12 V** means the calculated average price per one mA for either -12 V, + 5 V and +12 V per one mA of the module power consumption.

Price per one button means the calculated average price for one button from the total buttons of the module.

Price per one contact plate means the calculated average price for one contact plate from the total contact plates of the module.

Price per one encoder means the calculated average price for one encoder from the total encoders of the module.

Price per one knob means the calculated average price for one knob from the total knobs of the module.

Price per one pad means the calculated average price for one pad from the total pads of the module.

Price per one slider means the calculated average price for one slider from the total sliders of the module.

Price per one switch means the calculated average price for one switch from the total switches of the module.

Price per one CE means the calculated average price for one CE from the total CEs of the module.

Price per one input means the calculated average price for one input from the total inputs of the module height.

Price per one output means the calculated average price for one output from the total outputs of the module height.

Price per one IO means the calculated average price for one IO from the total inputs & outputs of the module height.

Price per one CE & IO means the calculated average price for one CE & IO from the total CEs & IOs together of the module height.

7.4 User interface experience

In the below subparagraphs all the parameters and characteristics will be explained in further details.

7.4.1 The look & the first impression

This requires no further explanation, here as a placeholder only.

7.4.2 The touch and the quality

This requires no further explanation, here as a placeholder only.

7.4.3 The user interface experience

This requires no further explanation, here as a placeholder only.

7.4.4 The patching

This requires no further explanation, here as a placeholder only.

7.5 Functionality overview

In the below subparagraphs all the parameters and characteristics will be explained in further details.

7.5.1 General functionality

The below example table provides an overview of the general functionality parameters.

Characteristic	Comment or value
Main function	VCO
Sub function(s)	n/a
Analogue or digital	analogue
Digital sample rate in kHz	n/a
Digital sample depth in bits	n/a
Chainable	no
Designer	n/a
Multiple	single
Bleeding	n/a
Trimmer - calibration	yes, see Doepfer's website

Table 31 - An example table of general functionalities

The **main function** and **sub function(s)** parameters have been explained already in subparagraph 7.3.2 - General module details.

Analogue or digital tells the reader if the module is analogue based, digital based or in case it's a bit of both a hybrid module. This is most of the time not always (clearly) indicated by the manufacturer, thus the author has to "estimate" this and might have guessed wrong, so please take this indicator not too serious and keep in mind it might not be correct. Feedback on correctness is of course welcome.

Digital sample rate in kHz is the sample rate that the module uses in case of a digital module and in case the manufacturer has provided this information (either on their website or in the user manual).

The same goes for the **digital sample depth in bits** that indicates the number of bits of each sample in case the module is digital.

Chainable means if the module can be "chained" with yet another same module, a classic example for that would be the Doepfer – A-138p module that can be chained with more A-138p modules or even with the A-135-4A/B module(s). Another example of a chainable module is the Xaoc Devices - Tirana module.

If the manufacturer indicated the name of the **designer** specifically for this module then the designer's name will be mentioned here otherwise "n/a" will be mentioned.

The **multiple** parameter indicates the number of the mentioned main function on that module. For example, with a dual VCO here for this parameter "dual" would be indicated. For a quad LFO here would be "quad" indicated, etcetera.

With **bleeding** is meant if the module “bleeds” or leaks or spills. That might not be applicable to all modules but filters, VCAs, mixers and other types of modules might bleed meaning that if the inputs & outputs of the module for the particular channel have been put to zero that one still can hear the sound of that channel. If that’s indeed the case then it’s bleeding or leaking the audio signal to the output that shouldn’t be the case.

Trimmer - calibration means there is a trimmer (usually a small screw that can be adjusted) that can be used to calibrate the module, this is usually for the 1V/oct input however it can trim other parameters too. It’s advisable not to touch this since it has been usually calibrated by the manufacturer already.

7.5.2 The LFO functionality

In the below example table, the most common LFO characteristics have been mentioned.

Characteristic	per CE	per IO	Comment or value
Frequency/rate	1 knob	n/a	~0.005 Hz - 4.5 kHz
Frequency range	1 switch	n/a	high, medium & low
Time range	n/a	n/a	~0.2 ms - 3.5 min.
Morphing	n/a	n/a	
Phase shift	n/a	n/a	

Table 32 - An example table of the LFO functionality

How the **frequency/rate** can be changed per which CE (if any) is mentioned in the **per CE** column and if it can be controlled via an input CV then that is mentioned in the **per IO** column. In the **comment or value** column, if provided in the manual or on the manufacturer's website then the frequency range is mentioned in that column.

In case the f**requency range** can be changed then that's mentioned here in this row.

The **time range** is similar to the frequency range in the **comment or value** column however instead of the range is mentioned in Hertz it is in time (seconds, minutes, etc.). The per CE and per IO are here not mentioned, only in the frequency/rate row.

If the LFO can do **morphing** between the different wave types then that's mentioned here.

Some LFOs have a phase shifted (also called wave shifted) output available, some examples of such modules are QLFO from ACL and the Black Octasource from Erica Synths. In case the reviewed module here has this option that that's mentioned at this **phase shift** row.

Wave type	Output	Comment or value
Clocked noise	n/a	
Cosine	n/a	
Envelope	n/a	
Flexible wave	n/a	
Pulse	n/a	
S & H/Stepped triangle	n/a	

Saw	yes	simultaneously
Saw - reversed	yes	simultaneously
Sine	yes	simultaneously
Square	yes	simultaneously
Trapezoid	n/a	
Triangle	yes	simultaneously

Table 33 - An example table of the LFO outputs

In the above example table the different LFO outputs have been displayed. In the first column **wave type** the type of wave (of the LFO's output) has been mentioned, in the middle column **output** it mentions if the corresponding wave type is available by this particular LFO module by either yes or n/a. In the last column **comment or value** additional information might be mentioned, like simultaneously meaning that more than just one output wave type at the same time is possible with this particular module.

Clocked noise or just noise wave type is one as it mentions already, a noisy one (if it would have been audible), i.e. kind of random; not many LFO modules offer this "wave type".

Cosine is a 90º in phase shifted sine wave.

Envelope is a wave type that "behaves" (and looks) like an envelope; for example an ADSR.

The **flexible wave** is a special one, it covers all other waves that haven't been mentioned here and that's, for the user, somehow flexible to create with this particular module.

Pulse is a wave type whereby only a positive "pulse" is produced, a (positive) trigger for example.

The difference between the **pulse** and the **square** is that the pulse is actually a positive pulse only (0 to +10 V for example) whereby the square has a positive and a negative pulse (i.e. from for example +10 V to -10 V and vice versa). Not for all LFOs this is clearly indicated in the manual. At least for this review report, it will be observed this way.

Please do note though that there are other definitions of pulse and square, like for example a square has an exact pulse width of 50% and a pulse is not (for example only 30%), however this definition has not been used here for this document. How it has been explained above here, that's how it's been used in this document.

S & H/Stepped triangle wave type is a wave type that looks indeed like a stepped triangle, therefore in some module manuals it's called S & H and others call it stepped triangle. There might be (minor) differences between the two however for this document this is considered to be the same.

Saw wave type speaks for itself, it's the saw wave.

Saw - reversed wave type is the saw but "the other way around", sometimes also called inverted saw or ramp.

Sine wave type speaks for itself, it's the sine wave.

Square wave type, see above at the pulse where the details have been explained between these two.

Trapezoid wave type is a wave that looks like a trapezoid.

Triangle wave type speaks for itself, it's the triangle wave.

7.5.3 The subfunction(s)

This requires no further explanation, here as a placeholder only.

7.5.4 The flow diagram

The author is not going to explain the flow diagram in details, the diagram should speak for itself however the legend of the diagram (in general, so not all items in the legend might be used in this particular flow diagram) will be explained here.

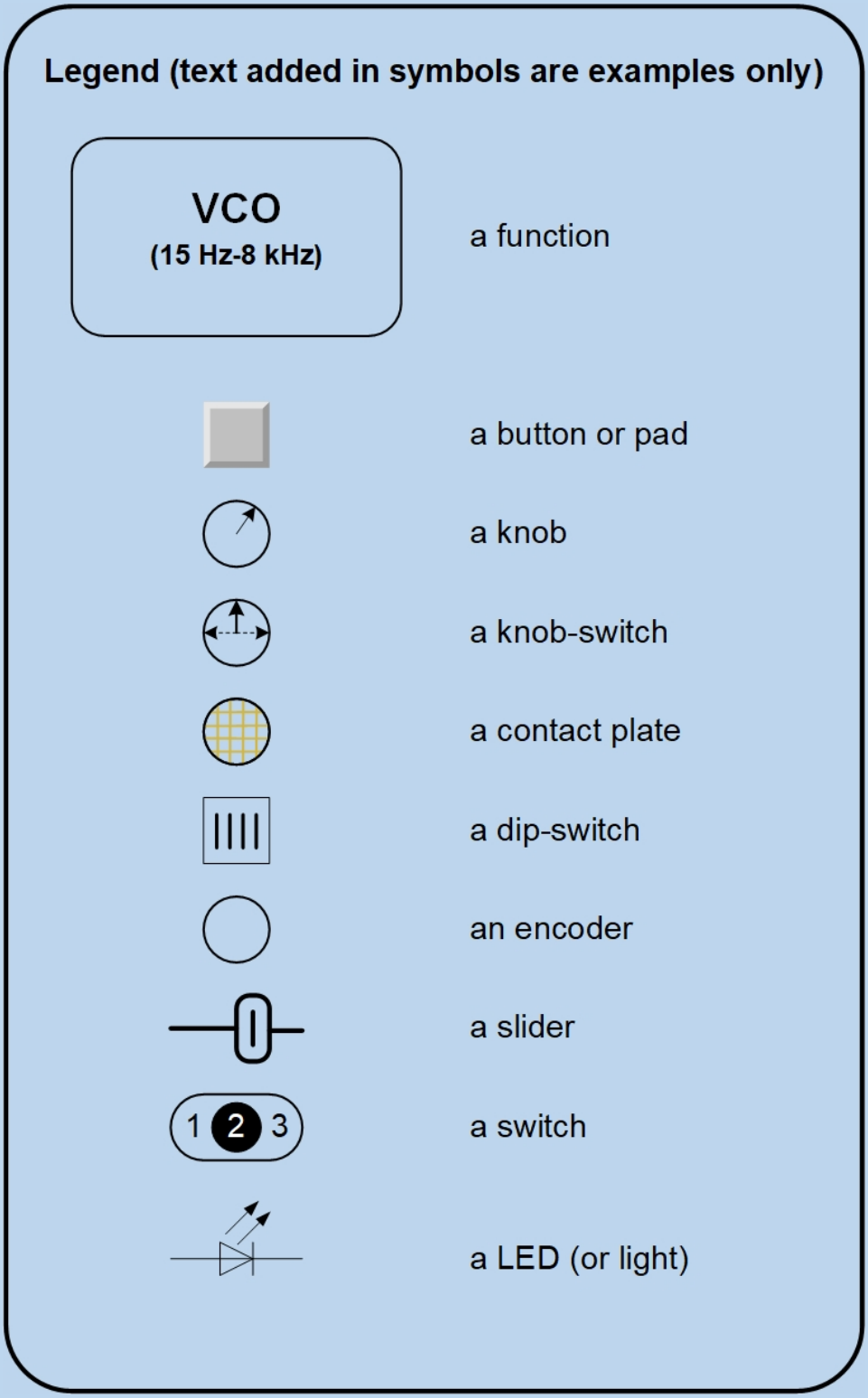


Figure 10 - Legend of flow diagrams, part 1

A function is represented by a square box with rounded corners, in the above example it's a VCO, but could be anything from VCA, VCF, VCS, to attenuator, S&H, EG, LFO, etcetera.

Below the function are the possible CEs displayed with their symbols and the textual explanation.

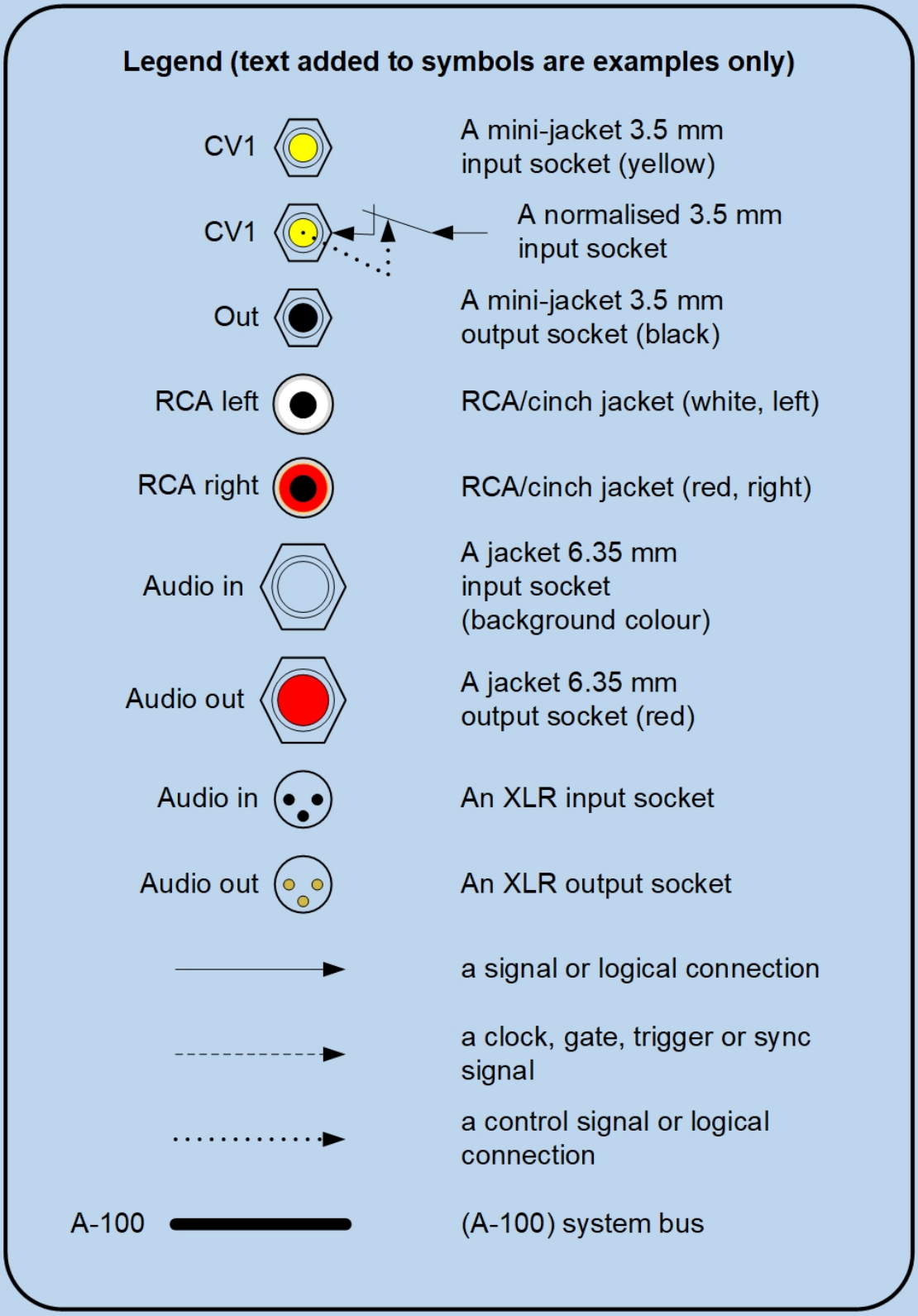


Figure 11 - Legend of flow diagrams, part 2

That 6-sided symbol (or hexagon) indicates an IO. The small hexagons are the mini-jacket 3.5 mm inputs (yellow inner-circle) & outputs (black inner-circle), whereby the larger hexagons are the 6.35 mm jackets for inputs (transparent inner-circle) & outputs (red inner-circle). Followed by the XLR input and XLR output sockets.

That mini-jacket 3.5 mm input symbol with the dotted line it in “controlling” a switch represents a normalised connection. If nothing has been plugged in, it’s as displayed here → the external input is then normalised here to the output of this IO. If a patch cable is plugged in this IO then the external input will be disabled (i.e. “switched off”); at least here in this legend. Needless to mention that this normalised connection is applicable to other IO types as well, it’s just mentioned here in conjunction with an input socket (one of the most common ones though).

A straight line (connection, possibly with arrow) is a signal “line” or logical connection. A dashed line represents a clock, gate, trigger or sync signal or connection. The dotted line indicates a control signal or logical line not related to a clock, gate, trigger or sync signal. A fat thick line represents a system bus, most likely the A-100 system bus.

It should be noted that the positions of CEs and IOs might not necessarily represent their correct positions on the module itself, the flow diagram is a logical interpretation of the module only.

7.5.5 Comparing this LFO module with other LFO modules

This subparagraph requires more modules of the same functionality. As soon as there are sufficient review reports ready for this functionality, this subparagraph will be extended for future LFO modules and explain the details where required.

For the moment this is a placeholder only.

7.6 Audio & sound experience

The possible patch diagrams used in this chapter use many symbols that are similar from the flow diagrams. For an explanation on those symbols please refer to: 7.5.4 - The flow diagram.

The wire colours in the patch diagrams are black for audio signals and blue for control signals, like CV, trigger, sync and clock signals.

7.6.1 Main LFO function default sound possibilities

This requires no further explanation, here as a placeholder only.

7.6.2 Sub function sound possibilities

This requires no further explanation, here as a placeholder only.

7.6.3 Possible interesting sound bits

This requires no further explanation, here as a placeholder only.

8 Appendix B - Glossary

Below an overview of abbreviations and used terminologies can be found with a small explanation.

Abbreviation or term	Explanation
%	percentage, see <x>%
©	Copyright symbol
±	symbol for plus/minus usually followed by a value, to indicate that the value should be taken as a range from minus that value till plus of that value
<x> mA @ <y> V	for example 90 mA @ +12 V means that the positive power line of 12 Volts "uses" (consumes the power) of 90 milli-Ampère
<x>%	percentage with parameter "x", for example 10% means 10 percent
~	symbol for about or roughly, usually in combination with a number, like ~8 means about 8
€	symbol for the Euro currency
ø	symbol for the diameter
1 PL	See chapter 7 - Appendix A for an explanation, it stands (only in Garfield Modular review reports) for 1 U modules from/compatible to Pulp Logic. Just "1 U" would be those 1 U modules from Intellijel for example
19" (rack)	19" (19 inch) rack is a standardised rack size, for example in the ICT and audio industries, i.e. for server, storage, audio, studio and other possible device types
8P8C	see RJ-45
A-<x>-<y>	Doepfer's system of numbering/naming their modules, nowadays in the format of, for example, A-140-1, whereby <x> is a three (3) digit number and <y> is usually a one (1) digit number
AC	Alternating Current
ADSR	Attack, Decay, Sustain and Release (EG module or function)
AH	Attack & Hold (might be related to Erica Synths - Black HADSR EG); see AHDSR
AHDSR	another type of EG: Attack, Hold, Decay, Sustain and Release (EG module or function)
AR	Attack and Release (EG module or function)
B	Byte, one Byte is 8 bits; see bit(s)
bit(s) or b	one bit is either zero or one in computing technology
BP_	the start of a document number (by Garfield Modular)
CE & IO	this means the Control Element(s) together with the Input(s) & Output(s), these CEs and IOs if mentioned in context being together or considered being together then CE & IO has been used in this document
CE(s)	Control Element(s), like a button, a switch, a knob, etcetera
cm	centimetre, 1 metre = 100 cm and 1 cm = 10 mm
cm^3	cube centimetre, volume of 1 * 1 * 1 cm
CV	Control Voltage, usually used to modulate (modular synthesizer) components
dB	decibel, unit of (sound/noise/audio) volume (amplitude) or power
DC	Direct Current

DCO	Digital Controlled Oscillator (module), this might be still voltage controlled though; it's just to make a difference between an analogue oscillator (hence VCO) or a digital oscillator (hence DCO)
dd-mm-yyyy	is the used date stamp format in this document, meaning: dd = day of the month, mm = month of the year and yyyy = year. For example, 10-11-2012 stands for the 10th of November 2012
depth	it usually refers to the depth of a module expressed in mm; see chapter 7 - Appendix A for details. It also might refer to the packaging depth though
DP or dp	Doepfer, a German brand of modular synthesizers and the creator of Eurorack (at least in context with modular synthesizers)
EDP	Electronic Dream Plant was a UK company by Chris Huggett and Adrian Wagner, known from the EDSP Wasp synthesizer
EG	Envelope Generator (module or function), often also called an ADSR or AR, etcetera, however ADSR or AR are just different types of EGs; there are many EG types...
EOA	End Of Attack indicates when the end of the envelope's attack stage has been reached. For Make Noise modules this might be also called EON or EOR
EOD	End Of Decay indicates when the end of the envelope's decay stage has been reached
EON	End Of Onset, terminology used by Make Noise, see EOA
EOP	End Of Phase, terminology used by Vermona, meaning the end of the entire EG has been reached; see also EOR
EOR	End Of Release indicates when the end of the envelope's release stage has been reached and usually with a classic ADSR that's the end of the entire ADSR envelope too; see also EOP End Of Rise, terminology used by Make Noise, see EOA
EOS	End Of Phase, terminology used by Vermona, see EOP
ES	Erica Synths, a Latvian brand of modular synthesizers
etc.	etcetera
Exp or exp.	Exponential (this might be FM related, like exponential FM)
filter	see VCF
FM	Frequency Modulation, the two common types are linear FM and exponential FM
g	gram, the module weight is indicated in grams
Garfield Modular	Garfield Modular, see https://garfieldmodular.net
GB (or GiB)	Giga Byte, in the early days defined as 1024^3=1,073,741,824 bytes or 1,024 MB, however nowadays the official 1 GB is called 1 GiB; the author still prefers to use the GB though manufacturers of hard disks and SD(HC) cards mean with 1 GB = 1 million KiB, thus not 1024 MB but 1000 MB and not 1 MB = 1024 kB but 1 MB = 1000 kB and 1 GB = 1000 MB... Thus... the possible indicated GB values of µSD cards are the "manufacturer" Giga Bytes and not the real Giga Bytes (real as in GiB)
GM	(see) Garfield Modular
HA	Hold & Attack (might be related to Erica Synths - Black HADSR EG); see HADSR
HADSR	Yet another type of EG: Hold, Attack, Decay, Sustain and Release (EG module or function)
HE	German for Höheneinheit and means U or RU; see U
height	it usually refers to the height of a module expressed in U, the default Eurorack module height is 3 U; see U. It might also refer to the packing height though
HP	Horizontal Pitch, meaning the width of a Eurorack module, in German also called TE. One (1) HP is equal to 5.08 mm
HPU	Horizontal Pitch Unit, it is the module surface in HPU defined as HP * U

HPUcm	Horizonal Pitch Unit centimetre, it is the module volume in HPUcm defined as HP * U * depth / 10 (since depth is in millimetres); see chapter 7 - Appendix A for details
HQ	Headquarters
Hz	Hertz, unit for frequency, one Hertz is exactly one cycle per second
i.e.	id est (Latin for "that is" or "in other words")
ID	identifier (number)
incl.	including
IO(s)	Input(s) & Output(s), the IOs of a module; see chapter 7 - Appendix A for details
k	kilo, one thousand (if not related to bytes otherwise 1,024 bytes = 1 k(i)B)
kB (or KiB)	kilo Byte, 1 kB = 1024 bytes; that's how it should have been but "officially", nowadays 1 kB = 1000 bytes and 1 kiB is the real kilo Byte, i.e. 1024 bytes; see GB
kHz	kilo Hertz = 1000 Hertz; see Hz
LCD	Liquid Crystal Display, till recently a common type of display type (either colour or monochrome), nowadays OLED and others exist too
LED	Light Emitting Diode, the most lights nowadays are of the LED type, not all though
LFM	Linear FM; see FM
LFO	Low Frequency Oscillator (module or function)
Lin	Linear (this might be FM related, like Linear FM)
LPG	Low Pass Gate (module or function)
mA	milli Ampère, 1 Ampère = 1000 mA
max	maximum
MB (or MiB)	Mega Byte, 1 MB = 1,024 kB, though officially 1 MB is nowadays 1,000 kB and the real Mega Byte is called MiB; see also GB
mHz	milli Herz, 1 milli Herz = 0.001 Hz
MIDI	Musical Instrument Digital Interface
min.	minute(s), most likely used in tables where there is too less space
Mk <x>	Mark <x> whereby <x> is the model or variant number
mm	millimetre, 1 metre = 1000 millimetre
mm^3	cube millimetre, volume of 1 * 1 * 1 mm
mmyy	Date stamp in the format of 2 digits month directly followed by a 2 digits year
mn or MN	Make Noise, a USA brand for modular synthesizers
mn-<x>-<y>	Make Noise's model or type system on their PCBs, usually <x> is a two (2) digit number and <y> is a three (3) digit number. For example, mn-00-045 that is the multiple "Mult" module of Make Noise
ms	milli second, 1 milli second is one thousandth of a second
n/a or N/A	not applicable, sometimes. (in tables) it might mean also no or zero (as a value of a parameter or characteristic)
oct	octave
PCB(s)	Printed Circuit Board(s), i.e. the usual green board that contains electronic components and with that creates a circuit; usually behind the front panel
PCI(s)	Power Consumption Indicator(s) related to the power consumption against several "indicators" (i.e. parameters)
peak	it usually refers to the "peak" value of a module, meaning the "highest" point of the module at the front panel side that "peaks out" of the module in mm; see chapter 7 - Appendix A for details
PW	Pulse Width, indicates the width of a pulse, however usually indicates Pulse Width Modulation and/or to indicate that the pulse width can be adjusted hence a knob on a module that comes with the text "PW"

PWM	Pulse Width Modulation is the modulation of a square wave that might be an optional function with some VCOs and other possible modules
Q	resonance, also Q or emphasis
Reset/sync	reset or sync (synchronisation) signal
RJ-45	RJ stands for Registered Jack, typical connector type for (Ethernet) network cables and connectivity though official it's the 8P8C connector however everyone calls it RJ-45 as does the author ;-)
RR	Review Report
RRP	Recommended Retail Price or in German the UVP, here in the document the definition of this term isn't taken too accurately, it is rather the "market price" found on the Internet of some well known shops with the indicated date
RU	Rack Unit, see U
SD (card)	Secure Digital (card), usually up till 2 GB
SDHC (card)	Secure Digital High Capacity (card), usually between 4 GB and 32 GB
S&H or S & H	Sample & Hold (module or function)
SH	See S&H
surface	it usually refers to the surface of the front plate of the module in HPU; see chapter 7 - Appendix A for details
sync	sync or synchronisation signal
TE	German for Teileinheit and means HP; see HP
TL;DR or TLDR	Too Long (or Lazy); Didn't Read. There seems to be a certain "TL;DR syndrome" under an increasing number of people, for those who suffer from the TL;DR syndrome: check out chapter 2 only. But honestly? If you suffer from the "TL;DR syndrome" modular synthesizers might not be your cup of tea (lots of reading required...)
traffic light	a "tool" to indicate how "good" or "poor" a parameter or rather characteristic is in the chapter the module summarised
U	(Rack) Unit, in German also HE, U or RU indicates the height unit of a 19" rack device. Default Eurorack modules are 3 U, i.e. 3 rack units height in a 19" rack
US$	The (USA) dollar, the official currency of the United States of America
USB	Universal Serial Bus, a (nowadays) typical "computer connector" type in many variations, in the document all "generalised" to USB unless of importance to mention the exact type or version
UVP	German for Unverbindlicher Verkaufpreis; see RRP
V	Volt, common voltages within the Eurorack system are +12 V (as in positive 12 Volt) and -12 V (as in negative 12 Volt), less common nowadays is +5 V
VCA	Voltage Controlled Amplifier (module or function)
VCF	Voltage Controlled Filter (module or function)
VCO	Voltage Controlled Oscillator (module or function)
VCS	Voltage Controlled Switch (module or function)
volume	it usually refers to the volume of a module in HPUcm; see chapter 7 - Appendix A for details. It might also refer to the packaging volume though or audio or sound volume
Vpp	Voltage peak-to-peak, for example 10 Vpp means from -10 V (minus peak) till +10 V (plus peak); which is Eurorack's default (max) Vpp value
WD or wd	Waldorf, German manufacturer of Eurorack modules and synthesizers in common
weight	it usually refers to the weight of a module in grams; see g or chapter 7 - Appendix A for details. It might also refer to the packaging weight though
width	it usually refers to the width of a module expressed in HP; see HP. It might also refer to the packing width though
XFM	Exponential FM; see FM

XLR	External Line Return, connector type for balanced audio signals
yyyy	Date stamp in the format of 4 digits year
yyyymm	Date stamp in the format of 4 digits year directly followed by a 2 digits month
µA	micro Ampère, one-millionth of one Ampère or one thousandth of a milli Ampère
µSD	Micro SD card, in this document SDHC might be meant as well (or other possible variations of a micro SD card)