



# random

modular quad true random voltage generator  
2022-04

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## 1 Introduction

The transistorkreis random is a quad true random voltage generator for modular synthesizers. Each of its four outputs can be switched to

- uniform or normal random distribution,
- unipolar or bipolar voltage range,
- an amplitude<sup>1</sup> of 5 V<sub>pp</sub> or 10 V<sub>pp</sub>.

There are two inputs to trigger new random voltages for output 1 to 3 and for output 4. They also process trigger signals with rates in the audio range. Hence the random module can also be used as a source for digital noise. The true randomness of the generated voltages is ensured by using the RNG<sup>2</sup> module of an STM32 microcontroller based on an unpredictable physical noise source.

The transistorkreis random is available as DIY kit for the Moog format (MU) and the Eurorack format. Its design is generic and also supports any other modular format. Figure 1 shows the front panel layout of the Moog and Eurorack version. The transistorkreis random features:

- an easy DIY assembly since all SMD<sup>3</sup> components are already soldered,
- only high-quality electronic and electromechanical components,
- a skiff-friendly Eurorack version,
- no tantalum electrolytic capacitors due to ecological reasons,
- an open-source firmware.

Modules from transistorkreis, distributed ready-made or as DIY kits, are in conformity with European health, safety, and environmental protection standards. Modules from transistorkreis or their components must not be disposed in the normal household waste. They must be disposed separately for proper treatment, recovery and recycling. Designated collection points will accept them free of charge. Please contact your local authority for details on your nearest designated collection point.



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<sup>1</sup>The amplitude is switched with a DIP switch on the main PCB.

<sup>2</sup>See application note [AN4230](#) from STMicroelectronics.

<sup>3</sup>surface-mount device

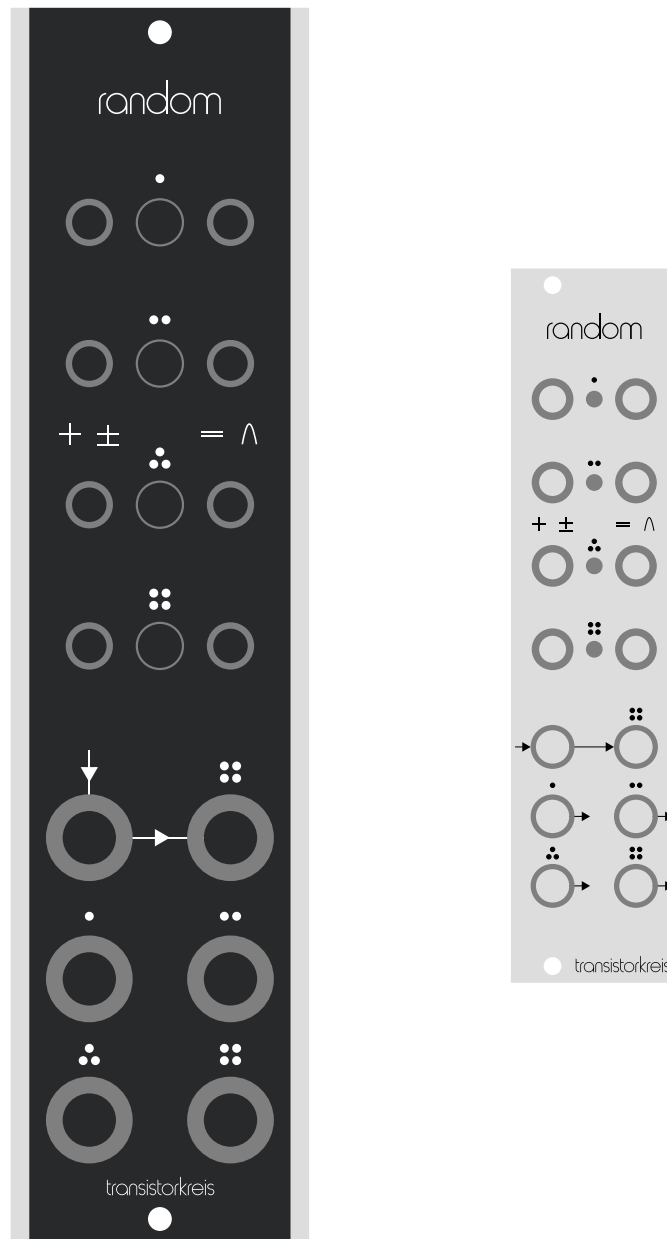


Figure 1: Front panel layout of the Moog and Eurorack version.

## 2 Operation

You are solely responsible for any damages and injuries caused by improper installation, operation or building of the module. Please follow the instructions in section 3 on how to build your random module.

### 2.1 Safety

Only install and operate completely operable modules. Do not expose your random module to humidity, mechanical shocks or strong vibrations. And do not operate it with an ambient temperatures above 40 °C. Conductive or corrosive liquids, gases, aerosols or vapours may damage or destroy your random module. Only use a correct and appropriate power supply for your module and your modular synth. Never connect headphones or any consumer audio devices to your module. Only connect your module to other modules of your modular synth to ensure that signal sources do not exceed the voltage range of the power supply of your module, for instance.

### 2.2 Installation

*Switch off the power supply of your modular synth  
before installing a new module.*

Make sure that the power supply of your modular synth has sufficient capacity to power all modules. Therefore, sum up the specified positive current consumption of all modules, including your random module. This is related to the +12 V or +15 V current branch depending on your modular synth. Do the same for the negative current consumption, i.e. for the -12 V or -15 V current branch. The current consumption should be specified in the manufacturer's technical specification for each module. And the current consumption of your transistorkreis random is listed in table 4 in section 5.1. Only proceed with the installation of your random module if none of the values exceed the specification of the power supply of your modular synth.

Use plastic washers for the fastening screws to avoid damaging the surface of the front panel of your random module.

## 2 Operation

### Installation of the Moog version

A  $\pm 15\text{ V}$  power supply and 6-pin MTA-100 connectors are used to power your system. See figure 2 on how to connect the power supply to your transistorkreis random. Make sure that the male and female connector are aligned and correctly orientated. Never use any violence to plug or unplug connectors. You should see a short front panel LED running light when your random module is powered up.

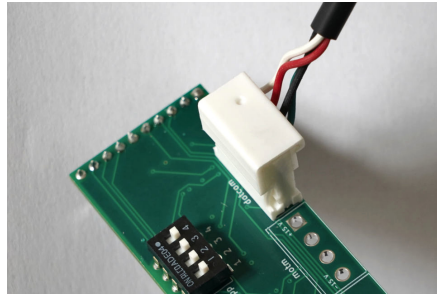


Figure 2: MTA-100 power connector

### Installation of the Eurorack version

A  $\pm 12\text{ V}$  power supply and IDC connectors are used to power your system. Use only the Eurorack power cable from transistorkreis to connect the power supply of your modular synth to your transistorkreis random. This power cable has a small and a large IDC connector. Connect the small IDC connector to the Eurorack power connector of the main PCB of your random module. This male connector on the PCB is shrouded to ensure a correct orientation and alignment of the connection. Respectively, the red wire of the power cable is located at the side of the connector that is marked with “-12 V”. See figure 3 on how the Eurorack power cable is connected to your transistorkreis random.

Connect the large IDC connector of the power cable to the power supply of your modular synth. Never use any violence to plug or unplug connectors and double check

- that the female connector of the power cable and the male connector of the power supply are aligned (no open pins) and correctly orientated,
- that the red wire of the power cable is located at the -12 V side of the male connector to avoid serious damage!

You should see a short front panel LED running light when your transistorkreis random module is powered up.

## 2 Operation

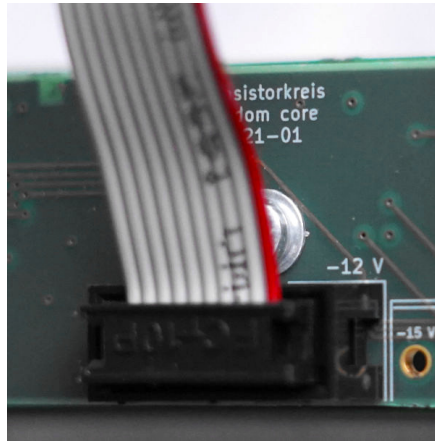


Figure 3: Eurorack power connector

### 2.3 Operating the module

There are two trigger inputs to trigger new random voltages:

- one input to trigger new random voltages for output 1 to 3 and
- a second input to trigger a new random voltage for output 4.

The first input is normalised to the second one, i.e. the first input triggers all four outputs if the second input is left unplugged. Both inputs can also process trigger signals with rates in the audio range.

There are three settings for each of the four outputs:

- Use one of the left-handed switches to set an output to unipolar (+) for only positive voltage values or to bipolar ( $\pm$ ) for positive and negative voltage values.
- Use one of the right-handed switches to set the voltage distribution of an output to uniform (=) or normal ( $\curvearrowright$ ). With uniform distribution all voltage values are of equal probability, whereas high or low voltage values are less likely with normal distribution.
- Use the DIP switch on the main PCB to set the peak-to-peak amplitude of an output, i.e. the difference between the lowest and highest possible voltage value. It can be set to 5 Vpp or 10 Vpp. Remove your module from your modular synth and refer to the PCB marking of the DIP switch to do so. Always switch off the power supply of your modular synth before removing your module!

## 2 Operation

Table 1 lists the resulting voltage ranges depending on the polarity and amplitude settings of an output. Those voltage ranges are applicable for both Moog and Eurorack systems. The default setting for the amplitude is 5 Vpp and should be sufficient for most patches. An amplitude of 10 Vpp can be advantageous for some applications, e.g. if a modulation destination can be controlled with  $\pm 5$  V and its whole modulation range shall be used. An amplitude of 10 Vpp saves an additional amplification in such cases.

Table 1: Output voltage ranges depending on polarity and amplitude.

	unipolar (+)	bipolar ( $\pm$ )
5 Vpp	0 V to 5 V	-2.5 V to +2.5 V
10 Vpp	0 V to 10 V	-5 V to +5 V

Note that a bipolar output can also be useful to modulate parameters that only accept positive voltage values, e.g. a filter resonance that is set to Zero. This scenario realizes a modulation that only takes effect for half of its values on average.

### 2.4 Patch examples

This section presents some ideas of what you can do with your random module. Please find a demo video on the transistorkreis [homepage](#) that presents the following patch examples.

#### CV source

Connect the gate signal, that is used to trigger a sound, to your transistorkreis random in order to trigger new random voltages when the sound is triggered. Use those voltages to modulate parameters of the sound, e.g. cutoff frequency and resonance of a filter, square wave pulse width, VCA gain, fader balance etc. This will add brio to the sound and is especially useful with periodic sounds and sequences. Figure 4 shows an example.

The polarity of an output should be unipolar if your random module shall only increase the modulated parameter, e.g. a filter resonance that is set to Zero. Switch an output to bipolar if your random module shall increase as well as decrease the modulated parameter, e.g. the cutoff frequency of a filter that shall vary around a certain value. Switch the distribution of an output to uniform if all possible voltage values are equally desirable. And switch it to normal distribution if extreme values, i.e. high and low voltage values, are less desirable and shall occur less often.

## 2 Operation

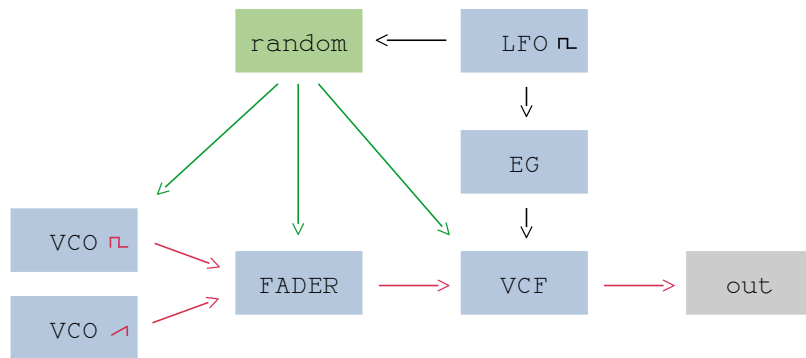


Figure 4: The transistorkreis random as a CV source.

### Digital noise oscillator

Connect a VCO to your random module to trigger new random voltages with rates in the audio range. Switch the distribution to uniform and the polarity to bipolar. Your random module functions as a digital noise oscillator now. An amplitude of 10 Vpp is not necessary, but advantageous since an audio instead of a modulation signal is generated. You can modulate the frequency of the VCO, e.g. with an LFO or an envelope generator, to reach certain effects. And you can also use a self-oscillating filter instead of a VCO to trigger your random module in the audio range. Figure 5 visualizes this patch idea.

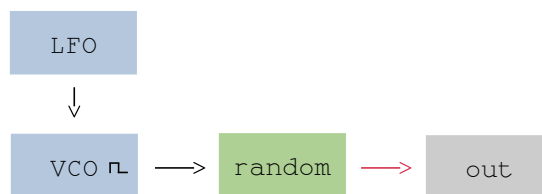


Figure 5: The transistorkreis random as a digital noise oscillator.

### Digital noise modulator

A digital noise modulator is similar to the digital noise oscillator in the previous subsection and your random module is also triggered with rates in the audio range. But for modulation purposes and in contrast to the digital noise oscillator the polarity of an output depends on the modulation destination. For instance, you can use the output of your random module to modulate the frequency and the pulse width of a square wave

## 2 Operation

VCO in order to create interesting timbres. In addition, the frequency of the triggering VCO can be modulated to reach certain effects. Figure 6 shows an example patch.

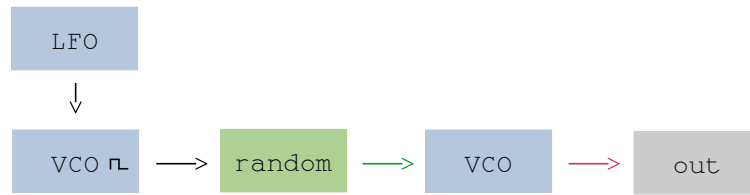


Figure 6: The transistorkreis random as a digital noise modulator.

### Random time intervals

Random time intervals can be generated by modulating the frequency of an LFO with a random voltage to make it constantly change its frequency. This LFO can now be used to trigger a sound and should, therefore, output a square wave. In addition, this LFO can trigger random voltages at the remaining outputs of your random module when the sound is triggered. And you can use these random voltages to modulate parameters of the sound, e.g. the cutoff frequency or resonance of a filter, the frequency of an oscillator, the pulse width of a square wave oscillator etc. Figure 7 shows an example.

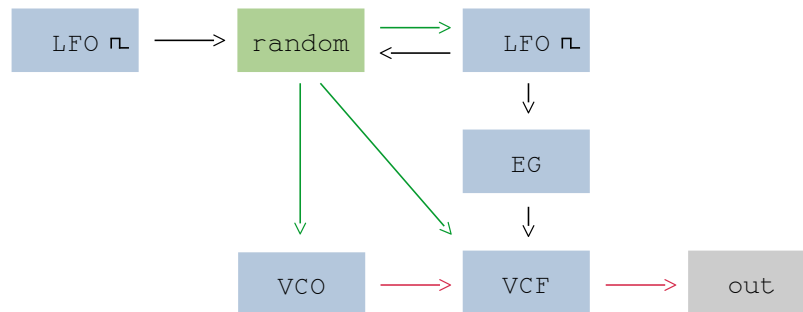


Figure 7: The transistorkreis random for random time intervals.

The polarity of the random voltage that modulates the LFO should be bipolar to increase as well as decrease the frequency of the LFO. Switch the distribution of the random voltage to uniform if all possible time intervals are equally desirable. And switch it to normal distribution if extreme values, i.e. very short and long intervals, are less desirable. Use the second input and, respectively, the fourth output of your random module to modulate the frequency of the LFO. New random voltages at output 1 to 3 can be triggered by the LFO via the first input.

## 3 Assembly

*Basic knowledge of electronics and soldering is mandatory.  
Use ESD prevention measures when you touch the main PCB.*

The electronics of the random module is placed onto only one main PCB, which is called Core PCB. Its electronics is ESD<sup>4</sup>-sensitive. You should use a grounded wrist strap and an anti-static mat when you touch its electronics. In addition to the Core PCB, there are auxiliary PCBs for the front panel components. Core PCB and auxiliary PCBs are connected via pin strips or ribbon cables. You do not have to solder SMD components to build the module.

Use RoHS<sup>5</sup>-compliant lead-free solder to preserve the RoHS compliance of the module.

### 3.1 Bill of material

Table 2 lists all components that are required to build the random module for the Moog (MU) and Eurorack (ER) format. This table also contains the PCB references of the components.

### 3.2 Preparing the Core PCB

The Core PCB is almost complete: All SMD components have already been soldered and the firmware for the STM32 has already been flashed and tested. You still have to solder the remaining components, see figure 8 and 9:

- the DIP switch SW1,
- the MTA-100 power connector J1 for the Moog version or the IDC power connector J3 for the Eurorack version,
- the male pin strips J5 and J6.

Make sure

- that you solder all components onto the PCB side where the outline of the respective component is printed,
- that the pin strips are soldered completely rectangular to the PCB surface,

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<sup>4</sup>electrostatic discharge

<sup>5</sup>Compliance to the Restriction of Hazardous Substances Directive is indicated by the CE marking.

### 3 Assembly

Table 2: Bill of material.

num	MU	ER	denomination	value or annotation	PCB ref
1	✓	✓	Core PCB	all SMD components placed	–
1	✓	✓	DIP switch	4 switches, 2.54 mm	SW1
2	✓	✓	male pin strip	1 row, 10 pins, 2.54 mm	J5-6
2	✓	✓	female pin strip	1 row, 10 pins, 2.54 mm	J1-2/J7-8
1	✓	✓	spacer	M3, 11 mm	–
2	✓	✓	screw M3	DIN 7985, 6 mm	–
3	✓	✓	washer M3	DIN 125 (0.5 mm thick)	–
1	✓	–	front panel	5 U/1 HP, aluminium, printed	–
1	✓	–	Control PCB	no components placed	–
1	✓	–	Jacks PCB	no components placed	–
1	✓	–	power connector	MTA-100, 6 pins (Dotcom)	J1
8	✓	–	switch & 2 nuts	SPDT, on-none-on	SW1-8
8	✓	–	toothed washer	suitable for the switch	–
8	✓	–	notched washer	suitable for the switch	–
2	✓	–	IDC connector	8 pins, 2.54 mm, male	J3, J7
2	✓	–	IDC connector	8 pins, 2.54 mm, female	–
1	✓	–	ribbon cable	8 conductors, 28 AWG, 7.5 cm	–
4	✓	–	LED	5 mm, red, 1.7 V, 2.0 mA	D1-4
4	✓	–	LED holder	VCC CMC_441_CTP	–
4	✓	–	toothed washer	suitable for the LED holder	–
4	✓	–	plastic nut	suitable for the LED holder	–
6	✓	–	mono jack & nut	Switchcraft 112APCX	J1-6
6	✓	–	washer	suitable for the jack	J1-6
6	✓	–	washer M10	DIN 125 (2.0 mm thick)	–
2	✓	–	washer M3	DIN 125, black plastic (mounting)	–
1	–	✓	front panel	3 U/6 HP, aluminium, printed	–
1	–	✓	ER PCB	no components placed	–
1	–	✓	power cable	Eurorack power cable, 16/10 pins	–
1	–	✓	power connector	IDC, 10 pins, 2.54 mm, male	J3
6	–	✓	mono jack & nut	Thonkicomm PJ398SM	J1-6
4	–	✓	LED	3 mm, red, 1.7 V, 2.0 mA	D1-4
8	–	✓	switch & nut	SPDT, on-none-on	SW1-8
8	–	✓	toothed washer	suitable for the switch	–
8	–	✓	washer M5	DIN 125 (1.0 mm thick)	–
2	–	✓	screw M3	DIN 7985, 6 mm (mounting)	–
2	–	✓	washer M3	DIN 125, clear plastic (mounting)	–

### 3 Assembly

- o that the orientation of the power connectors J1 and J3 is correct, see their printed outline on the PCB and figure 8.

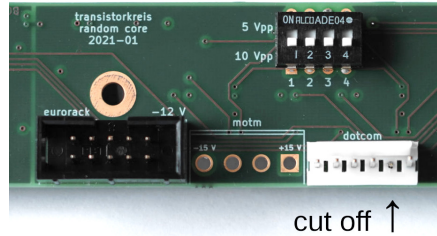


Figure 8: DIP switch and power connectors.

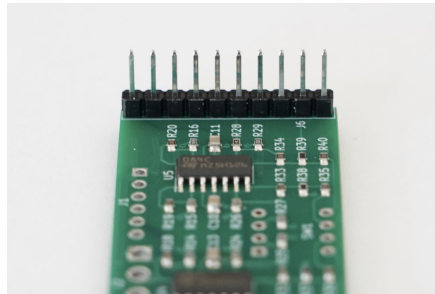


Figure 9: The male pin strips.

Pin 2 of the Moog power connector J1 must be cut off with a small side cutter. This pin is marked on the PCB and in figure 8.

### 3.3 Building the Eurorack version

There is one auxiliary PCB holding the front panel components. Make sure that you solder each component onto the PCB side where the outline of the respective component is printed.

At first you need to solder the female pin strips J7 and J8. You may plug on the Core PCB before you solder them in order to make them properly fit into their male counterparts on the Core PCB, see figure 10. Remove the Core PCB after you soldered the female pin strips.

Fix the spacer onto the PCB with a screw (M3) and with a washer on each side of the

### 3 Assembly

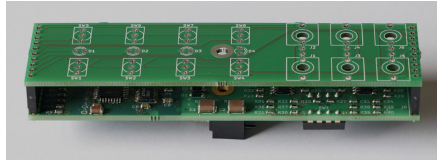


Figure 10: The plugged-on Core PCB when soldering J7 and J8.

PCB as shown in figure 11. Make sure that you put the spacer onto the PCB side where the pin strips are, see figure 12.

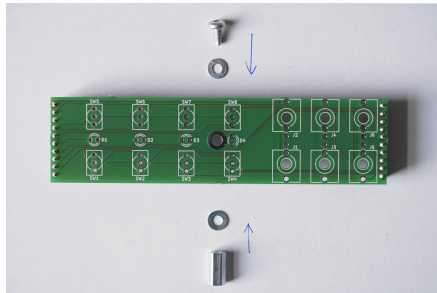


Figure 11: Fixation of the spacer.

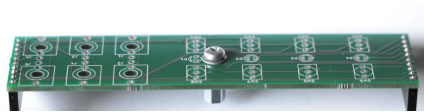


Figure 12: The fixed spacer and its orientation.

Put the leads of LED1 to LED4 through their solder pads. Make sure that the shorter leads, i.e. the cathode leads, are put through the rectangular solder pads, see figure 13. Do not solder them yet!

Put the switches SW1 to SW8 and the jacks J1 to J6 onto the PCB. Do not solder them yet! Put a washer (M5) and a toothed washer onto the switches, see figure 14 for the order of the washers. Put the front panel onto the switches and jacks, i.e. they are put into their drill holes. Use their nuts to fix the front panel loosely. Solder the switches and jacks and tighten their nuts properly now. Be very careful not to damage the front panel surface if you use a wrench or a pair of pincers to tighten the nuts.

Push the LEDs through their front panel holes, shorten their leads and solder them. Keep in mind that LEDs are heat-sensitive. Plug the Core PCB onto the auxiliary PCB. Double check the orientation of the PCBs and the alignment of the male and

### 3 Assembly

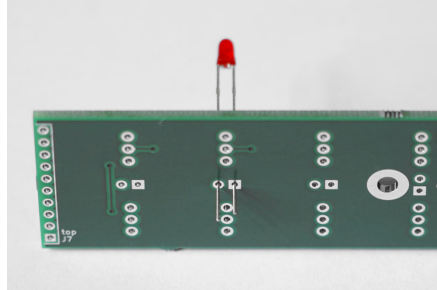


Figure 13: The rectangular solder pins for the LED cathode leads.



Figure 14: Switch with its washer and toothed washer.

### 3 Assembly

female pin strips: top to top, bottom to bottom and no open pins! Use the remaining screw and washer (M3) to fix the Core PCB to the spacer. The module is now completed. See figure 15 on how it should look like.

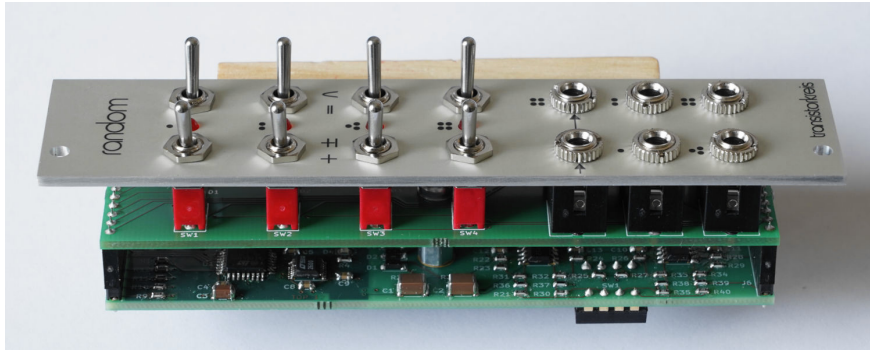


Figure 15: The completed Eurorack module.

#### 3.4 Building the Moog version

There are two auxiliary PCBs for the front panel components: one for the switches and LEDs and one for the jacks. They are called Control PCB and Jacks PCB. Control and Jacks PCB are connected with a ribbon cable with IDC connectors. And Control PCB and Core PCB are connected via male and female pin strips. Make sure that you solder each component onto the PCB side where the outline of the respective component is printed.

##### Control PCB

Fix the spacer onto the Control PCB with a screw and a washer (M3) on each side of the PCB as shown in figure 16. Fix the spacer onto the PCB side with the printed outline of J1, J2 and J3.

Solder the female pin strips J1 and J2. You may plug on the Core PCB before you solder them in order to make them properly fit into their male counterparts on the Core PCB, see figure 17. Remove the Core PCB after you soldered the female pin strips.

Solder the male IDC connector J3 and make sure that its orientation is correct. Therefore, have a look at the printed outline of J3 on the PCB: The notch of J3 points outwards as shown in figure 18.

### 3 Assembly

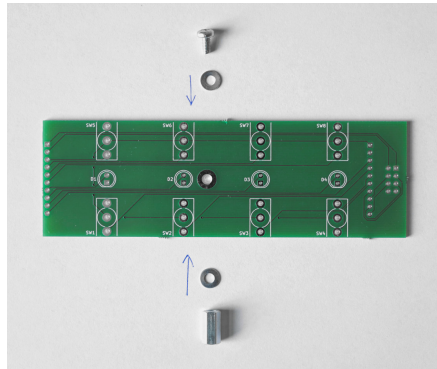


Figure 16: Fixation of the spacer.

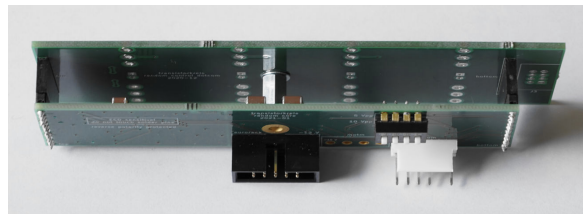


Figure 17: The plugged-on Core PCB when soldering J1 and J2.

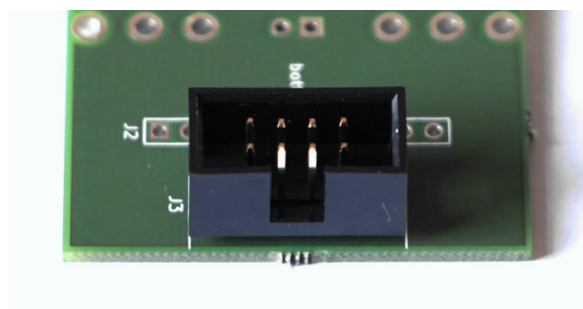


Figure 18: Orientation of J3.

### 3 Assembly

Put the four LED holders into their front panel holes and fix them each with a toothed washer and a plastic nut, see figure 19.

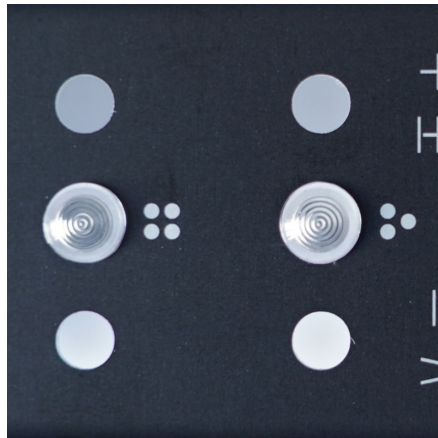


Figure 19: Front panel LED holders.

Put the leads of LED1 to LED4 through their solder pads. Make sure that the shorter leads, i.e. the cathode leads, are put through the rectangular solder pins, see figure 20. Do not solder them yet!

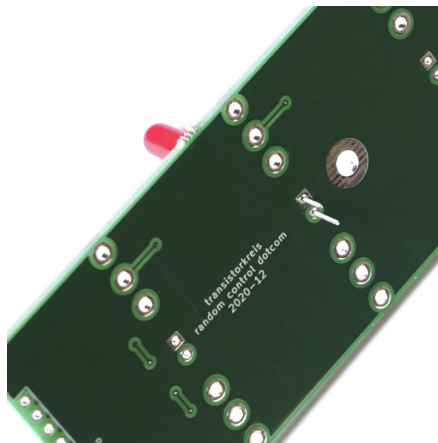


Figure 20: The rectangular solder pins for the LED cathode leads.

Screw a nut onto all switches and carefully tighten them with a wrench. Put the switches SW1 to SW8 onto the PCB. Do not solder them yet! Add a notched washer and a toothed washer onto the switches, see figure 21 for the order of nut and washers and figure 22 on how the Control PCB should look like now.

Put the front panel onto the switches, i.e. the switches are put into their drill holes.

### 3 Assembly

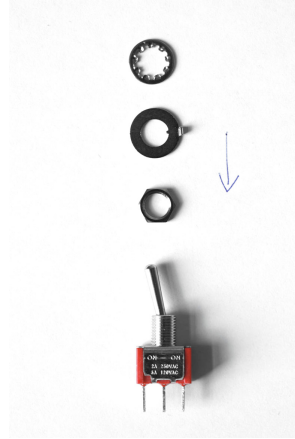


Figure 21: Switch with its nut as well as notched and toothed washer.

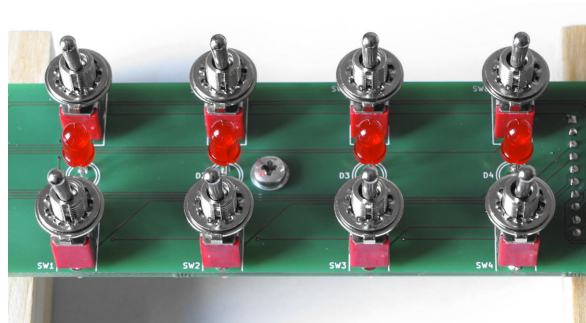


Figure 22: LEDs and switches placed onto the Control PCB.

### 3 Assembly

Make sure that the orientation of the front panel is correct: J3 at the bottom of the Control PCB points to the bottom of the front panel. Use an additional nut for each switch to fix the front panel loosely. Solder the switches and tighten their nuts properly now. Be very careful not to damage the front panel surface if you use a wrench to tighten the nuts.

Push the LEDs into their LED holders, shorten their leads and solder them. Keep in mind that LEDs are heat-sensitive.

#### Jacks PCB

Solder the male IDC connector J7 onto the Jacks PCB. Pay attention to the correct orientation of J7: The notch of J7 points to the PCB center, which is also indicated by its printed outline.

Put the jacks J1 to J6 onto the PCB. Do not solder them yet! Add a washer (M10) onto each jack as shown in figure 23.

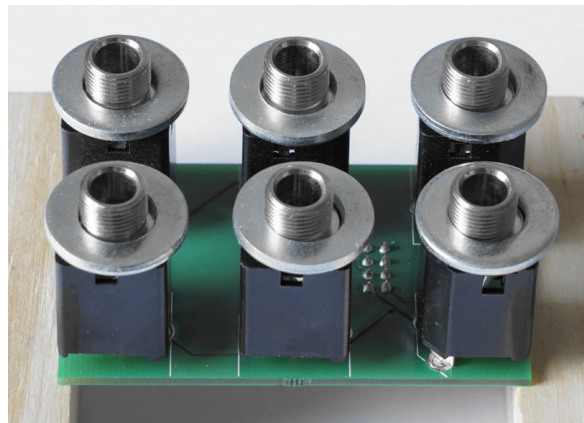


Figure 23: Washers placed onto the jacks.

Put the front panel onto the jacks, i.e. the jacks are put into their drill holes. Make sure that its orientation is correct, i.e. J1 and J2 are the inputs and IDC connector J3 points upwards respectively. Fix the front panel loosely with a washer and a nut for each jack. Solder the jacks and tighten their nuts properly now. Be very careful not to damage the front panel surface if you use a wrench to tighten the nuts. See figure 24 on how it should look like.

### 3 Assembly



Figure 24: The fixed front panel jacks.

Plug the Core PCB onto the Control PCB. Double check the correct orientation of the PCBs and the alignment of the male and female pin strips: top to top, bottom to bottom and no open pins! Use the remaining screw and washer (M3) to fix the Core PCB to the spacer.

#### Connecting the Control and Jacks PCB

A ribbon cable with IDC connectors is used to connect the Control and Jacks PCB. Put the 8-pin female IDC connectors together with their clips onto the outer ends of the ribbon cable as shown in figure 25. Double check the correct orientation of the connectors: Their centered stays must point into the same direction.

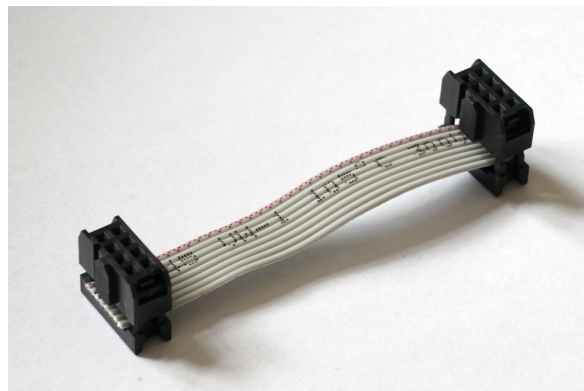


Figure 25: Orientation of the IDC connectors.

### 3 Assembly

Use a pair of pincers to carefully push the clips into the connectors and pay attention that the clips properly latch. See figure 26 for details.



Figure 26: Fixation of the IDC connectors to the ribbon cable.

Turn the ribbon cable around the top of the connectors and use the clips for the strain-relief for an additional fixation of the ribbon cable as shown in figure 27. The ribbon cable is now completed, see figure 28 on how it should look like. Plug the cable into the respective male IDC connectors in order to connect the Control and Jacks PCB, i.e. plug the cable into J3 of the Control PCB and J7 of the Jacks PCB.

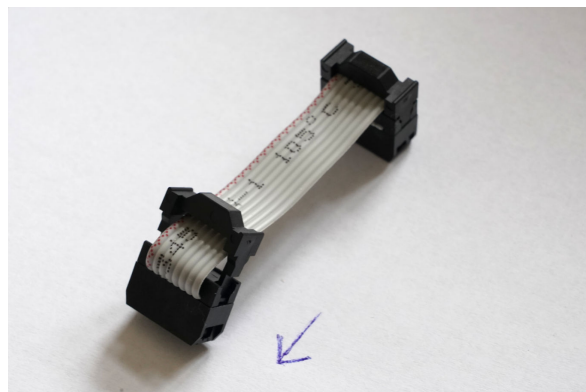


Figure 27: Fixation of the strain-relief.

The module is now completed. See figure 29 on how it should look like.

### 3 Assembly

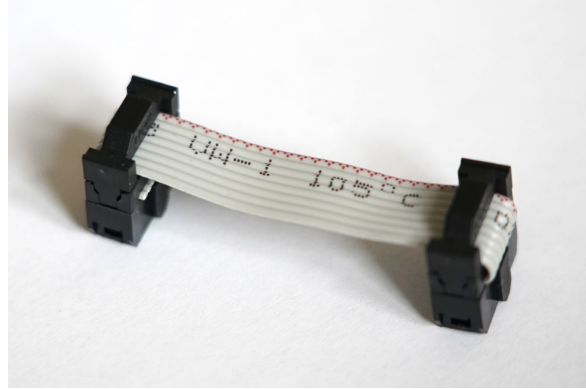


Figure 28: The completed ribbon cable.



Figure 29: The completed Moog module.

### 3.5 Support for other formats

*You are solely responsible for potential damages to your module or hardware when you build a customized version of the transistorkreis random.*

#### Other formats in general

The electronics of the transistorkreis random is placed onto the Core PCB, that is equal for all formats of modular synthesizers. You may design customized auxiliary PCBs for the front panel components and connect them to the pin strips of the Core PCB in order to build the random module for formats other than Moog and Eurorack. Therefore, breadboard-style PCBs may be useful since the pin strips of the Core PCB are aligned to 0.1 inch, respectively 2.54 mm. Table 3 lists the pin assignment of the male pin strips J5 and J6 of the Core PCB. Their first pin is marked each with a rectangular solder pad. Of course, it is also possible to connect the front panel components directly to the pin strips of the Core PCB if you can fix the Core PCB to the front panel directly. Use the centered drill hole of the Core PCB, that is used for the spacer with the Moog and Eurorack version, to do so.

The polarity of an output is set to bipolar if the respective polarity pin is connected to VDD and set to unipolar if it is unconnected<sup>6</sup>. The distribution of an output is set to normal if the respective distribution pin is connected to VDD and set to uniform if it is unconnected. All LED cathode terminals have to be connected to GND.

Table 3: Pin assignment of the Core PCB pin strips.

pin	J5 (top)	J6 (bottom)
1	input 1	VDD
2	input 2	GND
3	distribution 1	polarity 1
4	distribution 2	polarity 2
5	distribution 3	polarity 3
6	distribution 4	polarity 4
7	LED 1 anode	output 1
8	LED 2 anode	output 2
9	LED 3 anode	output 3
10	LED 4 anode	output 4

<sup>6</sup>It is set to GND with a pull-down resistor in this case.

#### **MOTM**

The Core PCB offers solder pads for an optional 4-pin MTA-156<sup>7</sup> MOTM<sup>8</sup> power connector. You might also use the Control and Jacks PCB of the Moog version, but make a slimmer front panel that fits the MOTM format.

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<sup>7</sup>TE Connectivity 640445-4

<sup>8</sup>Mother Of The Modulares, originally by Synthesis Technology.

## 4 Firmware

*You are solely responsible for potential damages to your module or hardware when you try to modify the firmware of your module.*

The firmware of the transistorkreis random module is written in C++ for an STM32L412 microcontroller and you may modify it in order to adapt it to your needs. For instance, you could implement an alternative random distribution or use the second input to switch any parameter instead of triggering a new random voltage for the fourth output.

The Firmware is published under the GNU GPLv3<sup>9</sup> license and provided as git<sup>10</sup> repository on github<sup>11</sup>. The firmware is organized as an STM32CubeIDE<sup>12</sup> project. Use the serial wire debug port J4 on the Core PCB to flash and debug the firmware.

Figure 30 shows an UML<sup>13</sup> class diagram of the firmware and all relevant classes and software units are listed below. Please find further information in the Doxygen<sup>14</sup> documentation in the source code.

- Eventhandler: Processes state machine events, e.g. input triggers and timer events.
- Animation: Realizes the front panel LED running light via a state machine.
- Generator: Generates uniformly or normally distributed random numbers.
- PcbStatusLed: Realizes the flashing of the SMD LED on the Core PCB.
- RngHandler: Manages random number buffers.
- Transmitter: Controls the front panel outputs and LEDs via SPI<sup>15</sup>.
- TIMER, GPIO, SPI, RNG: low-level HAL<sup>16</sup> drivers.

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<sup>9</sup>See <https://choosealicense.com/licenses/gpl-3.0/>.

<sup>10</sup>See <https://git-scm.com/>.

<sup>11</sup>The repository can be cloned from <https://github.com/transistorkreis/random>.

<sup>12</sup>See <https://www.st.com/en/development-tools/stm32cubeide.html>.

<sup>13</sup>Unified Modeling Language

<sup>14</sup>See <https://www.doxygen.nl/>.

<sup>15</sup>Serial Peripheral Interface

<sup>16</sup>Hardware Abstraction Layer



## 5 Further information

### 5.1 Technical data

Table 4 lists the most important technical data of the transistorkreis random.

Table 4: Technical data of the transistorkreis random.

quantity	value
supply voltage	$\pm 12\text{ V}$ to $\pm 15\text{ V}$
current draw (pos. and neg. draw)	+32 mA and $-15\text{ mA}$
front panel dimensions	5 U/1 HP (Moog), 3 U/6 HP (Eurorack)
depth (from front panel)	45 mm (Moog), 38 mm (Eurorack)
weight	227 g (Moog), 78 g (Eurorack)
input trigger threshold	800 mV
max. operating ambient temperature	40 °C

### 5.2 Contact

#### Manufacturer

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