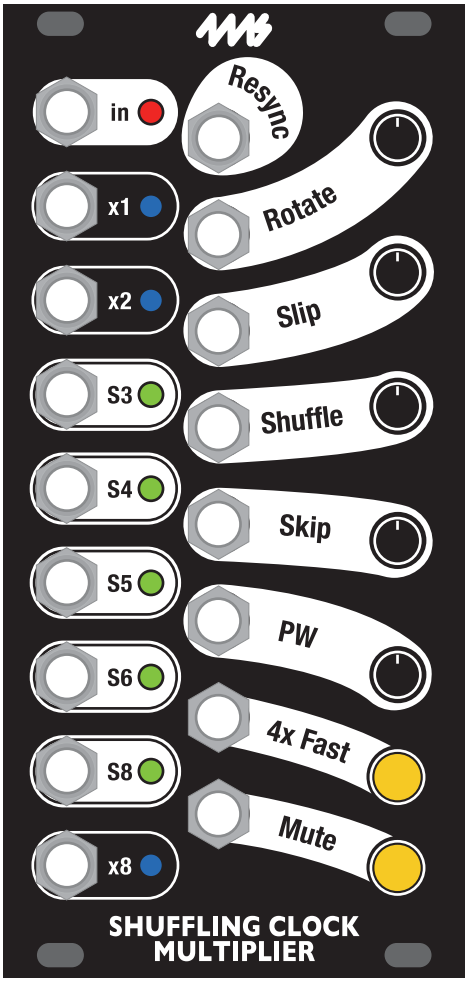
SCM Plus
4ms Company
User Manual 1.0a – Sept. 13, 2022



The **SCM Plus** is a clock multiplier with eight gate outputs and complex beat manipulation features. It combines the classic **Shuffling Clock Multiplier** (SCM) and **SCM Breakout** (SCMBO) into a single module using higher precision hardware than its predecessors.

SCM Plus features:

- Eight gate outputs, each multiplying up to x32
- Five slipped/shuffled/skipped clock outputs and three steady clock outputs
- Five knobs with CV jacks:
  - **Rotate** shifts multiply-by amount
  - **Slip** causes particular beats to land ahead in time
  - **Shuffle** selects which beats are affected by **Slip**
  - **Skip** omits certain beats in a pattern
  - **Pulse Width** controls width of output pulses
- **Resync** trigger input resets the slip/shuffle/skip counters
- **4x Fast** button and gate jack increase multiply-by amount by a factor of four
- **Mute** button and gate jack stop all outputs
- **Save Clock** feature restores last saved tempo when powering up
- **Clock Bus** jumper allows module to receive tempo from other modules over the power bus
- **Free Run** jumper allows unit to operate without an external clock
- LED dimmer trimpot allows for custom LED brightness
- 12HP Eurorack module

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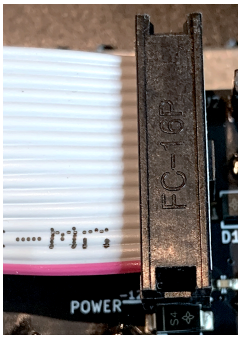
Setting up your SCM Plus

1. Power off your Eurorack system.
2. On the back of the **SCM Plus** you will see a 16-pin header. Connect one end of the included power cable to a 16-pin Eurorack power header on your power supply distribution board and the other end to the **SCM Plus** with the red stripe on the power cable oriented towards the bottom of the module.
3. Using the included screws, securely attach the **SCM Plus** to the rails of your case.
4. Power on your Eurorack system.



*Note: The **SCM Plus** is reverse-polarity protected, but incorrectly connecting any module in any system can damage other modules on the power bus.*

Clock Input Jack

The clock **In** jack is triggered by a rising edge of at least 2.5V. The light will blink red in time with the incoming clock signal.

Clock Output Jacks

The eight output jacks produce gates which can be used with a variety of Eurorack modules such as envelope or function generators, drum modules, sequencers, samplers, or anything that accepts a trigger, gate, or clock. They also can be used to open VCAs, ping resonant filters, or even as crude lo-fi audio signals.

x output jacks (**x1**, **x2** and **x8**) are the three steady clock outputs. These are not affected by **Slip**/**Shuffle**/**Skip** parameters. Their associated lights will blink blue in time with the outgoing clock signal.

S output jacks (**S3**, **S4**, **S5**, **S6** and **S8**) are the five slipped/shuffled/skipped clock outputs. Each is based on a multiple of the input clock frequency (x3, x4, x5, x6 and x8, respectively). Their lights will blink green in time with the outgoing clock signal.

Parameters

Resync

Applying a trigger greater than 2.5V to the **Resync** jack will cause the beat pattern to start over. The beat pattern is established by the **Skip**, **Slip**, and **Shuffle** parameters. **Resync** is not the same as a typical "Reset". A clock multiplier has no dedicated reset jack because it resets on every clock input pulse. That is, the pattern starts over every time a clock is received on the main **In** jack. The **Resync** jack allows for shifting the phase of the beat pattern so that it (re-)starts somewhere in between clock pulses.

Example Patch
The easiest way to hear this feature is to run a very slow clock into the clock **In** jack (try 4 seconds between pulses). Then turn **Skip**, **Slip**, and **Shuffle** to some randomly chosen setting. Next, plug a manual gate (eg: FSR-4 or Pressure Points or Choices) into the **Resync** jack. Listen to the **S8** jack and try to memorize the beat pattern. Now trigger the **Resync** jack and hear how the beat pattern instantly re-starts. It will re-sync itself back to normal when the next clock pulse appears on the **In** jack, so the new beat pattern will only last for less than one measure.

Rotate

The **Rotate** jack and knob rotate the clock multiply-by amounts throughout the output jacks (see Multiply-By Amounts Table on page 8).
With no rotation (knob turned down and no CV on the jack) the **x1** jack outputs a clock equal to the input clock, the **x2** jack outputs a clock twice the tempo of the input clock, the **S3** jack outputs a clock based on three times the input tempo, etc. up to the **x8** jack which outputs a clock eight times the input tempo. As rotation is applied by turning the knob up or applying CV to the jack, each jack's multiply-by amount shifts downward, wrapping back to multiply-by-eight after multiply-by-one. So when the knob is turned up a small amount, **x1** outputs a x8 clock, **x2** outputs a x1 clock, **S3** outputs a clock based on a x2 tempo, etc. up to x**8** which outputs a x7 clock. As more rotation is applied, **x1** outputs x7, **x2** outputs x8, **x3** outputs x1, etc. At maximum rotation, **x1** outputs x2, **x2** outputs x3, etc., up to **x8** which outputs x1.

When the jack is not patched, the the knob will set the amount of rotation. When a cable is patched into the jack, the knob attenuates the jack's signal. Turning the knob fully counter-clockwise will make the jack do nothing. Turning the knob fully clockwise will let a 3V signal on the jack perform the maximum amount of rotation.
Keep in mind that the "x" jacks always output steady clocks, and the S jacks always output slipped/shuffled/skipped clocks, no matter what amount of rotation is applied.

Slip

The **Slip** knob and jack shift every “n” beats forward in time. The value of n is set by the **Shuffle** parameter, and the amount by which each beat is late is set by the **Slip** parameter. For example, if n=2, then every other beat lands late: beats 2, 4, 6, etc…

When **Slip** is set to zero (when there is no CV signal or the knob is turned fully counter-clockwise) the **S** output jacks behave like the **x** output jacks, with no slipping or shuffling. However, **Skip** may still cause beats to drop out. Increasing **Slip** a small amount by turning up the knob or applying CV to the jack causes some beats to land slightly late. Turning the knob all the way up or applying maximum CV causes some beats to land right before the next beat.

When the jack is not patched, the the knob will set the amount of slippage. When a cable is patched into the jack, the knob attenuates the jack’s signal. Turning the knob fully counter-clockwise will make the jack do nothing. Turning the knob fully clockwise will let a 3.3V signal on the jack perform the maximum amount of slippage.

Internally, there's a counter that keeps track of whether each beat should be slipped or not. This counter resets itself on each input clock pulse. For example, if we have a steady clock input and we're slipping every other beat, beats 2 and 4 will be late on the **S5** output jack. If we have an input clock coming in before beat 6 is supposed to land, the counter resets, beat 6 becomes beat 1, and beat 1 is on time. So then beats 7 and 9 are late. The **Resync** jack resets this counter.

Note: Pulse Width (**PW**) affects how much slippage can occur. With very wide pulses, there's very little time between the end of a beat and the start of the next beat — therefore there's very little room to push the beat forward without encroaching upon the next beat. The shorter the PW setting, the more dramatic the **Slip** effect.

Shuffle

The **Shuffle** jack and knob work with the **Slip** parameter. While **Slip** controls the amount by which certain beats are pushed forward in time, **Shuffle** controls which beats are slipped. The default setting is every other beat (**Shuffle** at minimum). As you turn **Shuffle** up, every third beat will be slipped, then every fourth beat, fifth, sixth, and finally at a certain point in the knob's range, every seventh beat will be pushed forward. From this point in the range to maximum, **Shuffle** begins to push *groups of beats* forward instead of pushing just one beat forward. So next, a group of two beats are slipped, then a group of three, etc.

The knob sets an offset, and the jack signal is added to the knob's setting. When the knob is fully counter-clockwise, a signal from 0V to 5V on the jack will sweep the entire range of **Shuffle** patterns. When the knob is fully clockwise, a signal from 0V to -5V will sweep the entire range.

Skip

The **Skip** jack and knob are used to drop beats out of each measure. The concept of the measure is based on 8 beats. The jacks that output less than x8 are considered to be the first “n” beats of the measure (e.g. **S5** output jack is considered to be the first 5 beats of a measure). With **Skip** at minimum, all beats are played. As you turn the **Skip** knob up or apply a positive CV, more and more beats will be dropped.

The pattern of dropped beats is determined by a lookup table in the **SCM Plus** code. Each voltage corresponds to a particular pattern in the lookup table. There are 128 entries in the table, which range from 0 beats dropped, to each one of 8 beats dropped, to every permutation of 2 dropped beats, to every permutation of 3 beats dropped, to (nearly) every permutation of 4 beats dropped out of an 8-beat measure. Then the table is inverted, so that it continues to 5, 6, and 7 beats dropped. Dropping all 8 beats is avoided, since the **Mute** feature has this same functionality.

The knob sets an offset, and the jack signal is added to the knob's setting. When the knob is fully counter-clockwise, a signal from 0V to 5V on the jack will sweep the entire range of **Skip** patterns. When the knob is fully clockwise, a signal from 0V to -5V will sweep the entire range.

Pulse Width (PW)

The **PW** (Pulse Width) jack and knob effect all eight output jacks. With **PW** at minimum, each jack will output a very short pulse (1ms when frequency is under 1kH. This is enough to trigger most other modules. At the **PW** knob's center setting, the pulse width will be 50%, which is a square wave. In this state, the amount of time the waveshape is low is equal to the time it spends high. At its maximum setting, the pulse width becomes very long, in that it only blips low for about 300us. This is functionally an inverted trigger. One thing to watch out for with a very long pulse width is that the **Slip**/**Shuffle** parameters will have only a slight effect. This is because **Slip**/**Shuffle** push the beats forward in time without changing their pulse width. So when the width of the signal is very long and the gap between the pulses is very short, there isn't much room to move without completely closing the gap between pulses. Therefore, not much slipping can occur. To best hear the **Slip**/**Shuffle** effects, keep **PW** at 50% or less. Another way to think about this is that **PW** is a way to decrease the amount of **Slip** effect without changing the **Slip** parameter itself.

The knob sets an offset, and the jack signal is added to the knob's setting. When the knob is fully counter-clockwise, a signal from 0V to 5V on the jack will sweep the entire range of **PW**. When the knob is fully clockwise, a signal from 0V to -5V will sweep the entire range.

4x Fast

The **4x Fast** jack and button make every output run four times faster. The button will shine orange whenever this feature is engaged. Pressing the button will toggle the **4x Fast** feature, and so will applying a signal greater than 2.5V at the jack. When the button is off, a low voltage on the jack disables **4x Fast**, and a high voltage enables it. When the button is on, a high voltage turns **4x Fast** off, and a low voltage enables it. Said another way, any time the button is pressed or the jack signal goes high or goes low, the **4x Fast** feature will toggle states.

Example Patch: 4x Fast
Connect one of the **SCM Plus** outputs to the **4x Fast** input (e.g. try the **x2** jack). When the jack goes high, everything will speed up, including the signal you are currently sending to the **4x Fast** jack itself. So when this signal flips low, everything slows down. This is a very simple way to create a chaotic rhythm pattern. Playing with **PW** dramatically affects the pattern.

Mute

The **Mute** jack and button prevent any jacks from turning on. The button will shine orange when this feature is engaged. Any output jack that is already outputting a high signal will continue on its normal timing, but when it goes low it will stay low as long as the **Mute** gate is held high.
Pressing the button will toggle **Mute**, and so will applying a signal greater than 2.5V at the jack. When the button is off, a low voltage on the jack disables **Mute**, and high voltage enables it. When the button is on, a high voltage turns **Mute** off, and a low voltage enables it. Said another way, any time the button is pressed or the jack signal goes high or goes low, the **Mute** feature will toggle states.

Example Patch: Mute
Engaging the **Mute** function is the easiest way to kill the "light show" on the **SCM Plus** when it's not in use. But more useful (and blinding) is patching an **SCM Plus** output to the **Mute** jack. When the jack goes high, no new jacks will turn on, but when that jack goes low, normal play resumes. This drops out beats in a rhythmic semi-deterministic way. Playing with **PW** will affect the pattern dramatically.

Getting Started Patch

A good way to start is to first turn the knobs to their default settings: **Shuffle**, **Skip**, and **Rotate** all the way down (counterclockwise); **Slip** and **PW** centered. Press both buttons off so that **4x Fast** and **Mute** are not illuminated.

Run a slow clock into the **In** jack, and use the **S8** and **x8** output jacks to open two different VCAs, Low Pass Filters or Low Pass Gates. If you have envelope generators, patch **x8** and **S8** to the trigger input of envelope generators and then patch the envelope outputs to the VCA/LPF/LPG control inputs. If you don't have envelope generators you can just patch the **x8** and **S8** jacks directly to the control inputs on

the VCAs/LPFs/LPGs. Run sound sources into both VCAs/LPFs/LPGs and mix the outputs together so you can hear both at the same time. Make sure **Rotate**, **Shuffle**, and **Skip** are turned all the way down, and that **PW** is centered to 50%. Adjust to suit your ears. Now play with **Slip**, slowly turn the knob along its full range and listen to how every other beat from the **S8** jack lands later and later as you increase **Slip**. Next, nudge **Shuffle** up until the beat pattern changes. Play with **Slip** some more, and keep nudging **Shuffle** up and playing with **Slip**. Once you get a feel for all the possibilities with those two knobs, start playing with the **Skip** knob: you should hear some beats drop out of the **S8** output, but the **x8** output will continue thumping steadily along.

How it Works

The **SCM Plus** measures the time between the previous two pulses and uses that value to calculate the frequency of the clock signals on the output jacks. Applying a steady clock will produce an output clock of equal frequency on the **x1** jack, a clock of double the frequency on the **x2** jack, and a clock of eight times the frequency on the **x8** jack.

If the **Free Run** jumper is installed (see section below), you can simply send two clock pulses into the clock input, and the **SCM Plus** will run at that tempo indefinitely. There is inherently some tempo drift in taking this “tap tempo” approach. If your goal is to synchronize the **SCM Plus** to another clock, using a common input clock is recommended. The **SCM Plus** can handle rapidly changing clock signals, including complex waveforms that cross the 2.5V boundary at erratic intervals.
Three of the jacks will always produce regular clock pulses that are multiples of the input clock: **x1**, **x2**, and **x8**. These jacks are not affected by the **Slip, Shuffle** or **Skip** effects.
The other five jacks (**S3**, **S4**, **S5**, **S6**, **S8**) produce clocks that are also multiples of the input clock, but these jacks will “rag” the beat (**Slip** and **Shuffle**), as well as drop some beats out (**Skip**).

Notice there is no S7 jack. This tempo pattern can only be produced with the **Rotate** knob or jack. For example, looking at Multiply-by Amounts At Each Jack table on page 8, we see that 0.6V on the **Rotate** jack will make the **S6** jack output S7, or applying >2.9V will make the **S8** jack output the S7 pattern and the **x8** output x7. The reason for leaving out S7 was to make room for both **S8** and **x8**: playing a non-slipped and a slipped clock at the same time results in some fascinating phasing and variable-shifting effects, especially if **Slip** is modulated slowly and both tempos are heard side-by-side (see the Getting Started Patch above).

Saving the Clock

The current tempo can be saved and restored the next time the **SCM Plus** powers on with the **Free Run** jumper installed.
To save the current tempo, the following button sequence must be executed without allowing more than half a second between button presses:

1) Begin with the module not muted and no voltages toggling **Mute** or **4x Fast**.
2) Press and release **Mute** to engage Mute
3) Press and release **4x Fast**
4) Press and release **4x Fast** again
5) Press and release **Mute** to disable Mute

Whenever the **SCM Plus** turns on with the **Free Run** jumper installed, the last saved tempo is restored. Note that if you have a clock patched into the **In** jack or an active clock on the Clock Bus (and the Clock Bus jumper installed), the incoming clock will override the saved tempo.

Free Run Jumper

On the back of the module is a jumper labeled **Free Run**. When this jumper is installed, the **SCM Plus** will run whenever it’s not **Muted**, even if there is no external clock. This means that if you unpatch the **In** jack and/or stop the upstream clock, the **SCM Plus** will keep producing multiplied clocks at the last tempo it received. Those familiar with the legacy SCM module will recognize this as the default behavior of that module.
When the **Free Run** jumper is not installed, the clock outputs will stop after two full periods with no incoming clock pulses. That is, if the incoming clock has

pulses every second to denote a measure, then the **SCM Plus** will stop outputting clocks if two measures (two seconds) pass without a clock. Thus there always will be a two measure delay from when the incoming clock stops to when the **SCM Plus** stops when the **Free Run** jumper is not installed. If this lag is an issue, send a trigger into the **Mute** jack whenever the upstream clock stops.

Updating Firmware

The **SCM Plus** firmware can be updated by playing a special audio file into the PW jack.
When a firmware update is available, it will be posted on 4mscompany.com as a WAV file (or zipped WAV file).

1. Download the audio firmware file and prepare to play it on your computer or mobile device.
2. Set the volume to maximum, both in the system/OS controls and also in the audio player application.
3. Power off the **SCM Plus** and unpatch all cables.
4. Patch **x1** to **Resync**.
5. Patch the computer/device output to the **PW** jack (any mono or stereo cable will work).
6. Turn the **PW** knob to approximately 11:00 (a little bit counter-clockwise of center).
   - Note: If you have a 4ms **Listen IO** or other module that boosts line level to Eurorack level, run the audio through it before patching into the **PW** jack. Set the **PW** knob to 0 in this case.
7. Power on the **SCM Plus**.
8. The module should boot into bootloader mode, with the **In** light blinking steadily.
9. Begin playing the audio firmware file. You can monitor the signal by listening to the **x8** jack.
10. If the update fails, all the lights will flash rapidly. Adjust the PW knob and then press **4x Fast** once to try again.
    - If you are not using a line-to-Eurorack module, you may have to adjust **PW** and retry a few times before successfully updating the firmware. Typical **PW** knob positions range from 9:00 to 11:30. Try a few positions until it works.
11. When the update succeeds, the lights will blink in order, one at a time (slow chase sequence).

Troubleshooting:

- Make sure the volume on your device and app are at 100%.
- Try a different computer or device.
- Do not use sophisticated playback software such as Ableton, as these can inadvertently alter the encoded audio. Use the most basic playback program available.
- If you have an oscilloscope or a way to view waveforms, compare the output of the **x8** jack with the output of the computer or device. Adjust the **PW** knob until the pulses are similar (accounting for 10µs – 75µs of latency).
- Use a line-to-Eurorack conversion module such as the **Listen IO,** setting the **PW** knob to 0.

LED Dimmer Trimpot

On the rear of the module is a small trimpot which can be used to set the LED brightness. Use a tiny phillips head screwdriver (#2) to carefully adjust the trimpot. Do not use excessive force or a screwdriver that doesn't fit, or the trimpot could be damaged.

Clock Bus Jumper

Clock Bus is a 1:1 clock that runs along the gate pin of the Eurorack power bus. This feature allows for a compatible module to send a clock signal over the power bus, and for one or more modules to synchronize to this clock. The **MiniPEG**, **DLD**, and **QCD** from 4ms are all capable of sending a clock over the Clock Bus. Modules from other manufacturers that send Clock Bus are also likely to be compatible, such as the Malekko Varigate 8+.
On the rear of the **SCM Plus** is a jumper to enable receiving clocks over the Clock Bus. When this jumper is installed, clock pulses on the Clock Bus will be sent to the **In** jack as if they were patched directly into the jack. When a cable is plugged into the **In** jack, the Clock Bus signal will be ignored.

Multiply-by Amounts at Each Jack

Jacks	Voltage at Rotate Jack with Rotate Knob at 100%							
	<0.4V	0.4V - 0.8V	0.8V - 1.2V	1.2V - 1.7V	1.7V - 2.1V	2.1V - 2.5V	2.5V - 2.9V	>2.9V
x1	x1	x2	x3	x4	x5	x6	x7	x8
x2	x2	x3	x4	x5	x6	x7	x8	x1
S3	S3	S4	S5	S6	S7	S8	S1	S2
S4	S4	S5	S6	S7	S8	S1	S2	S3
S5	S5	S6	S7	S8	S1	S2	S3	S4
S6	S6	S7	S8	S1	S2	S3	S4	S5
S8	S8	S1	S2	S3	S4	S5	S6	S7
x8	x8	x1	x2	x3	x4	x5	x6	x7

Electrical and Mechanical Specifications

  - 12HP Eurorack format module
  - 0.95” (24mm) maximum depth (includes power cable)
  - 16-pin Eurorack power header
- **Power consumption**
  - +12V: 52mA max
  - -12V: 15mA
- **Clock Input**
  - 2.5V threshold
  - 40kHz maximum
- **Clock Outputs**
  - 12V gate outputs, rise/fall time approximately 1us
  - 40kHz maximum
  - Jitter (**x1** output): max 30µs < 120BPM, max 5µs >= 120BPM
  - Latency (clock in to **x1** output): 8µs worst-case, 3.5µs typical
- **CV Inputs:**
  - **Rotate**, **Slip**: Knob attenuates jack signal. Full range: 0V to +3.3V
  - **Shuffle, Skip, PW**: Knob offsets jack signal. Full range: -5V to +5V
- **Gate Inputs:**
  - **4x Fast, Mute**: 2.5V threshold. Button toggles state.