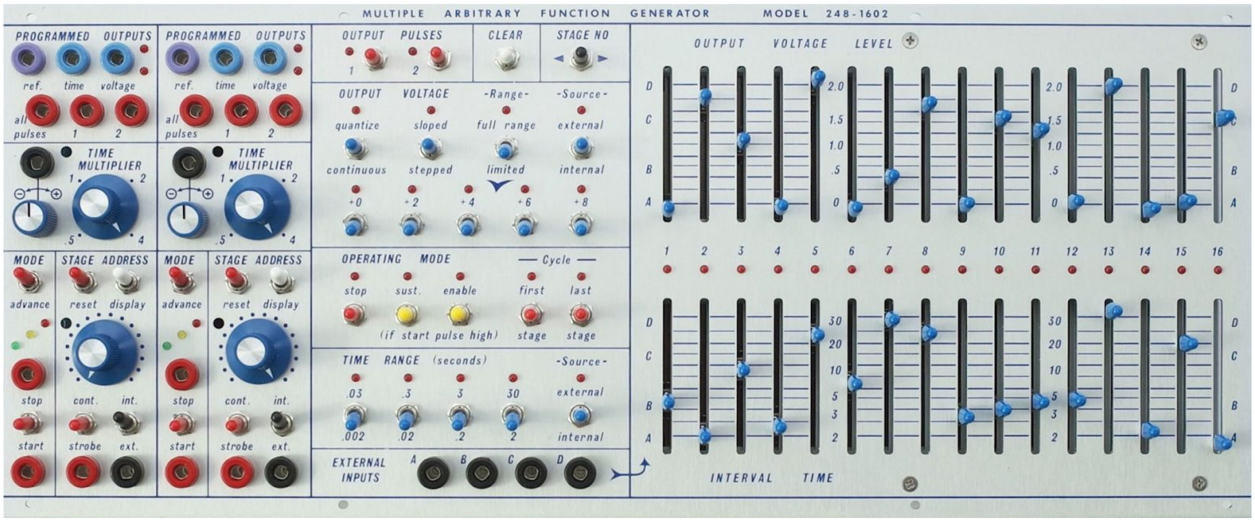

MULTIPLE ARBITRARY FUNCTION GENERATOR
MODEL 248-1602

Introduction

This book contains patches, or recipes, to help the musician get the most creative use out of the 248 Multiple Arbitrary Function Generator within a Buchla 200 series system. Reading the original manual and familiarity with the common operations is an important prerequisite for getting the most out of this material.

In contrast to the terseness of most Buchla technical documentation, the original 248 manual is surprisingly comprehensive. Nonetheless, today's reader may suffer somewhat from Don's bias against prescribing any particular musical approach to the aspiring composer, and the text is light on specific strategies to programming the module. Many popular features of other modular systems that do not have dedicated analogous modules in the 200 system can be replicated on the MARF. Through their own experimentation, some users have discovered especially fruitful approaches that aren't intuitively obvious to the amateur operator, and these are worth sharing more widely.

Contents

Conventions Used in the Patch Descriptions

The 248 consists of two identical sections called Arbitrary Function Generators, abbreviated AFG in this doc. Most patches can be executed on either AFG and so there is no mention of which to use. A smaller number of patches illustrate using both sections together, and in these the left and right AFG are referred to as AFG1 and AFG2 respectively.

Each AFG contains a large number of digital settings that modify the analog voltage settings, referred to as “level 2 programming” in the original manual. Programming the 248 is largely a process of figuring out which settings to apply to each stage to achieve the desired function. The table below shows the code used for each option, as well as a reminder of its usage. Each stage in a patch description contains a line in the table illustrating which “level 2” switches are set.

The settings marked **DEFAULT** are restored whenever a patch is cleared. When the default settings are used in a patch, they are usually omitted from the description, though sometimes they will be shown explicitly for illustrative purposes.

Tag	Panel legend	Usage
PULSE1	Output pulses 1	Pulse output on jack 1 when this stage is addressed.
PULSE2	Output pulses 2	Pulse output on jack 2 when this stage is addressed.
QUANT	Quantize	The voltage output is sampled at the beginning of the stage and quantized to .1v increments..
CONT	Continuous **DEFAULT**	The voltage output is continuous. Slider movements or external voltages are passed to the output.
SLOPD	Sloped	The voltage output slews to the stage’s new value
STEPD	Stepped **DEFAULT**	The voltage out jumps immediately to the stage’s new value.
FULL	Full range **DEFAULT**	The voltage output is full range 0-10v.
LIMIT	Limited	The voltage swing is limited to 1.2v plus an offset.
VEXT	External	The voltage output is determined by one of the external inputs.
VINT	Internal **DEFAULT**	The voltage is determined by one of the internal slider.
+0	+0	When limited, the voltage swing is 1.2v.
+2	+2	When limited the voltage swing is 1.2v + 1.2v.

+4	+4	When limited the voltage swing is 1.2v + 2.4v.
+6	+6	When limited the voltage swing is 1.2v + 3.6v.
+8	+8	When limited the voltage swing is 1.2v + 4.8v.
STOP	Stop	The internal clock will stop running once it reaches this stage.
SUST	Sustain	The internal clock will stop and hold when it reaches this stage as long as the start pulse is high.
ENABL	Enable	The internal clock will stop and hold when it reaches this stage unless the start pulse is high.
FIRST	FIrst stage	Sets the first stage of a cycle.
LAST	Last stage	Sets the last stage of a cycle.
TIME1	Time .002 - .03 sec	The stage time is .002 to .03 seconds.
TIME2	Time .02 - .3 sec **DEFAULT**	The stage time is .02 to .3 seconds.
TIME3	Time .2 - 3 sec	The stage time is .2 to 3 seconds.
TIME4	Time 2 - 30 sec	The stage time is 2 to 30 seconds.
TINT	Time internal **DEFAULT**	The stage time is determined by the internal slider.
TEXT	Time external	The stage time is determined by one of the external inputs.
STROB	Stage strobe	The stage is selected when a pulse is received
SCONT	Stage continuous	The stage is continuously swept
SINT	Stage internal	The stage is selected by the internal stage address pot
SEXT	Stage external	The stage is selected by an external voltage

Each AFG contains a number of inputs and outputs for control voltages and pulses. The following conventions and labels are used to refer to each.

ROUT	Reference voltage **CV OUTPUT**	Emits a falling ramp voltage, from 10v to 0v, duration equal to the time of the stage.
TOUT	Time output **CV OUTPUT**	Emits a CV, from 0v to 10v, proportional to the stage time.
VOUT	Voltage output **CV OUTPUT**	Emits the primary, programmed voltage output.

APOUT	All pulses output **PULSE OUTPUT**	Emits a timing pulse at the start of each stage.
P1OUT	Programmed pulse 1 **PULSE OUTPUT**	Emits a pulse at the start of a stage when the **PULSE1** switch is set.
P2OUT	Programmed pulse 2 **PULSE OUTPUT**	Emits a pulse at the start of a stage when the **PULSE2** switch is set.
TMIN	Time Multiplier **CV INPUT**	Accepts a control voltage input, with a reversible attenuator, for external control over the AFG's time base multiplier.
STOP	Mode stop pulse **PULSE INPUT**	Accepts an external pulse to stop the AFG, which has the same effect as the **STOP** switch.
START	Mode start pulse **PULSE INPUT**	Accepts an external pulse to start the AFG, which has the same effect as the **START** switch.
STROB	Stage address strobe pulse **PULSE INPUT**	Accepts an external pulse to "strobe" the stage address feature, causing the AFG to jump immediately to a new stage.
SEXT	Stage address external pulse **CV INPUT**	Accepts an external control voltage to drive the stage address in **SEXT** mode.
EXTA	External voltage A **CV INPUT**	External voltage input A. Shared between both AFGs.
EXTB	External voltage B **CV INPUT**	External voltage input B. Shared between both AFGs.
EXTC	External voltage C **CV INPUT**	External voltage input C. Shared between both AFGs.
EXTD	External voltage D **CV INPUT**	External voltage input D. Shared between both AFGs.

Buchla 200 System Voltage Standards

Pulses

Pulses in a buchla system can be in one of *three* states:

1. HIGH: 10v for ~1ms indicates the start of the pulse.
2. HOLD: 5v for any amount of time indicates the pulse is still active.
   This is also sometimes called SUSTAIN.
3. LOW: 0v indicates the pulse is off.

A keyboard pulse, either from a Kinesthetic Input Port or from a MIDI note utilizes all three stages. Some modules (such as the 248) do not send the 2nd HOLD state. Note that all of the pulse outputs on the MARF are of this simpler “trigger” variety.

Control voltages

Control voltages are from 0-10v. Negative voltages are never used.

There are *three* standards for mapping CVs to pitches possible by setting internal switches in the 248: 1v/octave, 1.2v/octave and 2.0v/octave. While the panel legend uses 2.0v/octave for historical accuracy, this manual uses 1.2v/octave exclusively as it is the most common modern standard in the community. Note that 0.1v in this standard normally produces a half-step change in pitch when sent to a properly calibrated oscillator.

Lookup Tables

Stage Address

When using stage addressing from an external control voltage, the input range of 0v to 10v is mapped (sort of linearly) to the 16 steps. The following lookup table can be used to program appropriate voltages to choose each of the 16 steps. Note that this control is poorly calibrated and nonlinear on many 248 modules and so you may have to adjust these values for your own unit.

1	0.0v	**5**	2.6v	**9**	5.1v	**13**	7.6v
2	0.7v	**6**	3.2v	**10**	5.7v	**14**	8.2v
3	1.3v	**7**	3.8v	**11**	6.3v	**15**	8.8v
4	1.9v	**8**	4.4v	**12**	6.9v	**16**	9.4v

Limited Range Voltages

When using external voltages in limited range mode, the incoming 0-10 volts will be scaled down to 0-1.2v, and quantized into half-steps of pitch change. The following lookup table can be used to program appropriate voltages for each half step.

0	0.0v	**+.3**	2.6v	**+.6**	5.1v	**+.9**	7.6v
+.1	0.9v	**+.4**	3.4v	**+.7**	5.9v	**+1.0**	8.4v
+.2	1.7v	**+.5**	4.2v	**+.8**	6.7v	**+1.1**	9.2v

Use the extra space in the tables above to note the values that work for you on your unit.

Leading vs Following

The 248 is most versatile in conjunction with other sequencers (or more generally, sources of pulses and voltages) in an overall Buchla system. The patches collected here can be loosely divided into two categories: those in which the 248 is the leader vs those where it is the follower. It may help to first present these two concepts before diving into the patches themselves.

248 as the Leader

As the 248 includes two very flexible clocks, it is a good choice as the primary source of timing information in a patch, driving secondary sequencers as followers. In this configuration, use the internal (**TINT**) time source, set by the lower rank of time sliders to configure the desired timing patterns. Use the **APOUT** or programmed pulses **P1OUT** and **P2OUT** to clock follower sequencers or to trigger events.

248 as the Follower

The 248's time base is unquantized, and all time adjustments must be set by ear. When working with very regular meters (*techno!*) better results may be achieved by using a steady leader clock and having the 248 follow the leader.

In this configuration, another module provides a regular (or not) source of external timing pulses which determine the timing of advancing through the 248's stages. This is usually achieved by patching the leader's pulses to the **START** input, and setting all (or most) of the 248's stages to **STOP** mode. There are many variations of this approach to be explored.

248 following the Keyboard

Driving the 248 with a keyboard pulse can be considered a variation of the follower mode. In this configuration, the pulse from a keyboard (218 or otherwise) is connected to the **START** input and the envelope is shaped by the onset and release of the keypress. While using the 248 this way requires some programming, its enormous flexibility makes up for the absence of traditional synthesizer envelopes in the 200 system.

248 as Addressable Memory

A final, related approach is to simply treat the 248's stages as addressable memory. A continuous control voltage of any shape can instruct the 248 to move through its stages directly following the CV. This is enabled by putting the STAGE ADDRESS into **CONT** (continuous) and **EXT** (external) mode. A voltage applied to the **EXT** input sweeps the module through all 16 stages.

TRADITIONAL SHAPES

Test your grasp of the basics first by recreating some traditional analog synthesizer features on the 248. The 200 series didn't include some of the traditional functions popularized by other manufacturers, but we can recreate anything with just a few steps on the MARF.

You can use either of the programmed outputs for these patches. These free-running LFOs use the internal clock, so use the **START** and **STOP** switch to toggle the cycle on and off.

Square Wave LFO

Patches	VOUT → Any mod destination

Step	Volt	Time	Data
1	10.0	5.0	STEPD FIRST
2	0.0	5.0	STEPD LAST

We only need the first two steps. Adjust the amplitude with slider 1 voltage, and the duty cycle with slider 2 time.

Sawtooth Wave LFO

Patches	VOUT → Any mod destination, eg pitch cv in.

Step	Volt	Time	Data
1	10.0	0.0	STEPD TIME1 FIRST
2	0.0	5.0	SLOPD LAST

By changing the second step to SLOPD mode, the pulse becomes a saw. Control the LFO period with the second time slider. Want it to rise instead of fall? Reverse the positions of the two voltage sliders.

Triangle Wave LFO

Patches	VOUT → Any mod destination, eg pitch cv in.

Step	Volt	Time	Data
1	0.0	5.0	SLOPD FIRST
2	10.0	5.0	SLOPD LAST

Put both steps into SLOPD mode to create a flexible triangle shape. Explore the different LFO shapes you can travel through by moving both voltage and time sliders, creating different offsets and modulation depths.

Free Running Free Form LFO

Stage Address	
Patches	VOUT → Any mod destination

Step	Volt	Time	Data
1	1.0	5.0	SLOPD
2	7.0	5.0	SLOPD
...	...	..	...
15	3.0	5.0	SLOPD
16	10.0	5.0	SLOPD

If you omit the first and last instructions, you will have a 16-step free running LFO of any shape. Adjust all sliders to suit. Use the time base knob to adjust the period of the overall shape.

ENVELOPES

These patches create simple, traditional voltage shapes which work well as amplitude envelopes. Send the voltage output to your 292(e) levels inputs.

The envelope requires a trigger, so send a keyboard or sequencer pulse into the **START** input. While you are programming, you can also just use the **START** toggle switch as a convenient trigger.

ADSR

Stage Address	
Patches	Trigger pulse → START VOUT → 292 level

Step	**Volt**	**Time**	**Data**
1	10.0	1.0	SLOPD FIRST
2	5.0	5.0	SLOPD SUST
3	0.0	5.0.	SLOPD LAST STOP

The useful and universal ADSR envelope shape is mentioned in the original manual, and is easily programmed in three steps.

The “attack” control is slider 1 time. The “decay” control is slider 2 time. The “sustain” control is slider 2 voltage. The “release” control is slider 3 time. The “spotlight” LEDs on the AFG will indicate whether it is running (green), in hold/sustain (yellow) or sto

AHDSR

Stage Address	
Patches	Trigger pulse → START VOUT → 292 level

Step	Volt	Time	Data
1	10.0	1.0	SLOPD FIRST
2	10.0	1.0	STEPD
3	5.0	5.0	SLOPD SUST
4	0.0	5.0.	SLOPD LAST STOP

The slightly fancier variation adds an additional step between the attack and decay stages, where the envelope holds high for a time before falling. This can be good for adding more punch to the attack of some percussive sounds. Adjust the length of this extra stage with the second slider time.

4x AHDSR

Stage Address	STROB SEXT
Patches	Trigger pulse → START VOUT → 292 level Optional Trigger pulse → STROB Program voltage → SEXT

Step	Volt	Time	Data
1	10.0	1.0	SLOPD
2	10.0	1.0	STEPD
3	5.0	5.0	SLOPD SUST
4	0.0	5.0	STEPD STOP
...	...	...	...
13	10.0	1.0	SLOPD
14	10.0	1.0	STEPD
15	5.0	5.0	SLOPD SUST
16	0.0	5.0	STEPD STOP

Obviously, since the AHDSR shape only uses 4 steps, we can fit four of them in sequence. Omit the **FIRST** and **LAST** modes, and each pulse will trigger each envelope sequentially. Craft four subtly different shapes to add variation to simple patterns, or make each shape wildly different.

Want to explicitly select one of the four programmed envelopes for each note? Set the STAGE ADDRESS to **STROB** and **SEXT**. Send the key pulse to both **START** and **STROB** inputs. Program an external voltage to select either stages 1, 5, 9, or 13 and send that to the **SEXT** input. Consult the lookup table above for mapping 10v to the 16 steps. If that CV doesn't land exactly on the stage start, you might jump into the middle of one of your envelopes and have unpredictable results.

8x Envelopes with Velocity

Patches	Trigger pulse → START VOUT → 292 level

Step	Volt	Time	Data
1	10.0	0.0	STEPD TIME1
2	0.0	2.0	SLOPD STOP
...	...	...	
15	10.0	0.0	STEPD TIME1
16	0.0	2.0	SLOPD STOP

Squeeze eight simple percussive envelopes into one AFG. Send a trigger pulse to trigger each. The first voltage slider controls the amplitude (velocity) of each note. The first time slider in each pair controls the time that the envelope is held at the max. The second time slider controls the length of the decay.

Two caveats: the second voltage slider should always be zero if you want the envelope to decay to nothing. Also, remember that a long time setting can inhibit quick triggering. The next stage cannot be started until the last has completed. So keep those beeps and boops short to move fast.

Remember with these multiple envelope patches that you can always use FIRST and LAST settings to shrink one AFG's cycle size down so that you can reserve some of the sliders for the other.

SEQUENCERS

While the 248 is often thought of as a “sequencer,” we’ve already seen that it can be used for a wide range of other applications. Now we’ll turn to examining how it can be applied musically to the problem of building sequences of notes. Keep in mind that the design of the MARF predates MIDI by many years, and thinking of it as a replacement for a MIDI sequencer will be disappointing. However, you’ll find that it can easily do many things that a note-oriented MIDI sequencer can not.

This section is organized somewhat more methodically than the others. Each patch is categorized in two ways: whether it is a leader or follower function, and how many stages it supports.

- Recall that leader patches use the internal clock in one of the AFGs as the primary timing reference. So adjusting the time base of that AFG will influence the overall timing of the sequence.
- Follower patches use an external pulse as the primary timing reference, so that each event in the sequence waits for a new pulse to arrive. There are many possible sources of external pulses in a system: a keyboard press, a cycling 281 or another sequencer.

The notation that we use for describing the type of sequence patch is AxBxC where:

- The first number A refers to the number of AFG sections used (1 or 2)
- The second number B refers to the number of usable voltage outputs per AFG (1 or 2)
- The third number C refers to the number of stages (eg. 8 or 16).
  But note that most patches can also be programmed for an atypical number of stages. For instance many older buchla modules had 5 step sequencers.

Finally, a useful trick in this section is to set a voltage output to masquerade as a pulse output. Recall that the Buchla standard pulse that is used in the 200 series has *three* states!

1x1x16 Leader with Variable Stage Time

Stage Address	AFG1 time base knob determines tempo AFG1 START/STOP
Patches	AFG1 **VOUT** →Any CV destination, eg pitch AFG1 **APOUT** → Any pulse destination, eg 281

Step	Volt	Time	Data
1	*any*	*any*	
2	*any*	*any*	
...	*any*	*any*	
16	*any*	*any*	

The simplest approach is to allocate all 16 sliders to AFG1 and to program a series of voltages on the upper sliders, and the duration for each on the lower sliders. The time base knob is used to adjust the speed of the overall sequence. Use AFG1's **START** and **STOP** switch. The **APOUT** pulse output can be sent to any envelope to shape each note.

1x2x8 Leader with Gate

Stage Address	AFG2 time base determines tempo. AFG2 START/STOP
Patches	AFG1 **VOUT** →Any CV destination, eg pitch cv AFG1 **TOUT** →Any CV destination, eg timbre cv AFG2 **VOUT** → Any pulse destination, eg 281 AFG2 **P1OUT**→ AFG1 **START**

Step	**Volt**	**Time**	**Data**
1	*any*	*any*	AFG1: STOP FIRST
2	*any*	*any*	AFG1: STOP
...	*any*	*any*	AFG1: STOP
8	*any*	*any*	AFG1: STOP LAST
...	*n/a*	*n/a*	
14	10.0	0.0	AFG2: TIME1 FIRST PULSE1
15	5.0	5.0	AFG2: TIME2
16	0.0	5.0	AFG2: TIME2 LAST

Often a regular step time is more desirable, and this patch is perfect for this case. AFG1 has steps 1-8 configured to output two distinct voltages, though any number of stages from 2-13 is possible. These outputs can be used to control two separate parameters, eg two of pitch, timbre, level, etc. AFG2 is the leader clock, looping the last three stages 14-16 for each cycle.

The AFG2 **VOUT** output is programmed to masquerade as a buchla pulse output, and this signal can be sent to any buchla pulse input, eg on the 281.

The duty cycle of the note events is determined by the ratio of the time sliders on stages 15 and 16. The overall tempo of the sequence can be adjusted with the time base knob on AFG2. Use AFG2's **START** and **STOP** switch.

1x2x8 Leader with Shuffle

Stage Address	AFG2 time base determines tempo. AFG2 START/STOP
Patches	AFG1 VOUT →Any CV destination, eg pitch cv AFG2 TOUT →Any CV destination, eg timbre cv AFG2 VOUT → Any pulse destination, eg 281 AFG2 APOUT→ AFG1 START

Step	**Volt**	**Time**	**Data**
1	*any*	*any*	AFG1: STOP FIRST
2	*any*	*any*	AFG1: STOP
...	*any*	*any*	AFG1: STOP
8	*any*	*any*	AFG1: STOP LAST
...	*n/a*	*n/a*	
15	5.0	2.0	AFG2: TIME2 FIRST
16	0.0	1.0	AFG2: TIME2 LAST

Many sequencers implement a shuffle (or swing) feel to humanize stiff, robotic patterns and this feel is essential to some genres of music. We can tweak the 1x2x8 patch above to create an 8 note sequence that plays with a shuffle feel.

Again the AFG2 serves as the leader clock, and its time base will determine the overall tempo. The relationship between the time settings of stages 15 and 16 will control the depth of the shuffle feel. Try it first with both sliders at 1.0, and then slide 15 up to 2.0 and 16 down a bit. You should be able to hear that the 1 and the 3 are taking a little longer than the 2 and the 4. Adjust to taste!

While not shown here, the voltage output of AFG2 could also be programmed to provide a tempo-synced LFO shape to use as an additional modulation source.

2x2x8 Follower

Stage Address	
Patches	Pulse in → AFG1 START Pulse in → AFG2 START AFG1 VOUT → Any CV pitch AFG1 TOUT → Any CV destination AFG2 VOUT → Another CV pitch AFG2 TOUT → Another CV destination

Step	Volt	Time	Data
1	*any*	*any*	AFG1: STOP TIME1 FIRST
...	*any*	*any*	AFG1: STOP TIME1
8	*any*	*any*	AFG1: STOP TIME1 LAST
9	*any*	*any*	AFG2: STOP TIME1 FIRST
...	*any*	*any*	AFG2: STOP TIME1
16	*any*	*any*	AFG2: STOP TIME1 LAST

This basic patch is easy enough to understand. Two 8-step sequences emit 2 distinct CVs each. Drive them with the same pulse or two different leader pulses.

1x2x16 Follower with Velocity

Stage Address	
Patches	Pulse in → AFG1 **START** AFG1 **VOUT** →Any CV pitch AFG1 **TOUT** → 292e velocity AFG1 **APOUT** → 292e level

Step	Volt	Time	Data
1	*any*	*any*	AFG1: **STOP** **TIME1**
2	*any*	*any*	AFG1: **STOP** **TIME1**
...	*any*	*any*	AFG1: **STOP** **TIME1**
16	*any*	*any*	AFG1: **STOP** **TIME1**

This patch provides a 16-step sequence, driven by an external pulse (eg another sequencer), with control over the pitch of the note on the upper slider and the velocity/level of the note on the lower slider. The **APOUT** output provides a simple descending ramp to the level input of a 292 and the lower slider provides the velocity cv on the **TOUT**. So no additional envelope module (eg a 281) is needed for a basic percussive sequencer sound.

Another nice feature of this patch is that the pulses don't really need to be programmed, as setting the lower slider to 0 essentially mutes the step. This is a simple patch, but one of the most straightforward and useful approaches for percussive arpeggio patterns.

2x1x16 Follower as a Canon

Stage Address	
Patches	Pulse in → AFG1 START Pulse in → AFG2 START AFG1 **VOUT** →CV 1 pitch AFG2 **VOUT** → CV 2 pitch

Step	Volt	Time	Data
1	*any*	0.0	AFG1: STOP TIME1 AFG2: STOP TIME1
2	*any*	0.0	AFG1: STOP TIME1 AFG2: STOP TIME1
...	*any*	0.0	AFG1: STOP TIME1 AFG2: STOP TIME1
16	*any*	0.0	AFG1: STOP TIME1 AFG2: STOP TIME1

This patch is similar to the 1x2x16 except that we will use both AFG sections to create canon-like patterns. Both AFGs address the same pattern of 16 notes, so they will play the same motif. However, distinct pulse patterns can be sent to each AFG producing interesting variations. Another approach is to send the same pulse to both AFGs, but play the **ADVANCE** switch on AFG2 so that one pattern continuously slips against the other, producing different variations.

Another way to use this patch is to set one or both of the AFGs into **LIMIT** mode and to use the octave transposition switches (eg +2, +4, +6) to move one of the lines up or down in octaves.

1x2x8 Follower with Envelope

Stage Address	
Patches	Pulse in → AFG1 **START** AFG1 **VOUT** → Any CV destination, eg 261e pitch cv AFG1 **TOUT** → AFG2 **TMIN** AFG2 **VOUT** → Any CV destination, eg 292e level cv AFG1 **APOUT** → AFG2 **START**

Step	Volt	Time	Data
1	*any*	*any*	AFG1: **STOP** **TIME1** **FIRST**
2	*any*	*any*	AFG1: **STOP** **TIME1**
...	*any*	*any*	AFG1: **STOP** **TIME1**
8	*any*	*any*	AFG1: **STOP** **TIME1** **LAST**
...	*n/a*	*n/a*	
13	10.0	1.0	AFG2: **SLOPD** **FIRST**
14	10.0	1.0	AFG2: **STEPD**
15	5.0	5.0	AFG2: **SLOPD** **SUST**
16	0.0	5.0	AFG2: **SLOPD** **LAST** **STOP**

This combo patch uses AFG1 as an 8-step sequencer and AFG2 as an AHDSR that triggers on every step of the sequence. The time voltage from AFG1 is sent to the Time Multipler of AFG2, so that the time slider increases the overall time of AFG2's envelope.

Alternately, the patch can be adjusted so that it only affects 1 stage time in the envelope (eg the hold time on step 14) for other effects. Patch AFG1 **TOUT** to **EXTA** and set step 14 to **TEXT**.

PATCHES of UNCERTAINTY

The following patches require a source of random control voltages, for example a 265, 266(e) Source of Uncertainty (SOU). While the SOU is capable of adding plenty of uncertainty on its own, combining it with the AFG can create expressive patches with very playable control over the texture of the randomness.

There are two basic principles behind these patches:

- Random strobe: using the SOU voltage to strobe the AFG to a random step (STROB SEXT modes), so that each stage's characteristic is applied randomly.
- Random external voltage: the SOU voltage is sent to the external inputs A-D and some or all stages are set to choose the external input (VEXT mode).

The random patches are shown using all 16 stages, but they can work equally well with less if the random strobe voltage can be processed into a smaller range, eg 5v for 8 steps.

SOURCE OF UNCERTAINTY MODEL 266e shown for reference

Random Timbre Modulation

Stage Address	STROB SEXT
Patches	Trigger pulse → STROB Trigger pulse → SOU SOU (any CV out) → SEXT VOUT → Timbre CV on 259, 261, etc.

Step	Volt	Time	Data
1	0.0	0.0	STEPD
2	1.0	0.0	STEPD
...	*any*	0.0	STEPD
16	2.0	0.0	STEPD

Add variation to a sequenced part by using the AFG to provide random timbre modulation. The SOU voltage is sampled on every pulse, and the AFG will jump to a random stage, choosing a random voltage from the possible 16.

This can be more musically compelling than the evenly quantized voltages available from the QUANTIZED RANDOM VOLTAGES output of the 266e, as there are myriad possible distributions to explore. For example, most steps can be set at 0.0 and only a few with higher voltages. These events will “jump out” of a sequence, seeming to create a second pattern within the first.

If the STORED RANDOM VOLTAGES output of the 266e is used, then the SKEW knob can be used to bias the random stage selection to the lower or higher stages. Keep CHAOS fully clockwise to equally weight all the stages.

Random Octave Transposition

Stage Address	STROB SEXT
Patches	Trigger pulse → STROB Trigger pulse → SOU Pitch sequence → EXTA SOU (any CV out) → SEXT VOUT → Pitch CV in on 259, 261, etc.

Step	Volt	Time	Data
1	0.0 (A)	0.0	QUANT STEPD VEXT LIMIT +0
2	0.0 (A)	0.0	QUANT STEPD VEXT LIMIT +2
...	...	0.0	QUANT STEPD VEXT LIMIT Any offset
16	0.0 (A)	0.0	QUANT STEPD VEXT LIMIT +4

Unlike the timbre patch, in this configuration the pitch sequence CV takes a detour through the AFG on the way to the oscillator.

The AFG can scale, offset and slew the voltages applied to the external inputs and certain aspects of this are optimized for managing pitches. The limited voltage range constrains the external voltage to an octave of pitch CV (1.0v, 1.2v or 2.0v depending on your configuration) plus an additional 1, 2, 3 or 4 octaves depending on the offset switch. Additionally, the quantized mode (QUANT) snaps the output voltage to a half-step (typically 0.1v increments) which will have good results when sent to the pitch CV input of an oscillator that is properly tuned and calibrated.

Set all of the voltage sliders to 0.0 (A) so that each stage passes the pitch CV from the external input. Now, randomly set a number of the offset switches on some of the stages. As the AFG strobes through the stages, the sequence will jump octaves randomly. The musical effect is to again create the illusion of multiple lines from a monophonic source.

Random Arpeggiator

Stage Address	STROB SEXT
Patches	Trigger pulse → STROB Trigger pulse → SOU Constant voltage → EXTA Constant voltage → EXTB Constant voltage → EXTC Constant voltage → EXTD SOU (any CV out) → SEXT VOUT → Pitch CV in on 259, 261, etc.

Step	Volt	Time	Data
1	0.0 (A)	0.0	QUANT STEPD VEXT LIMIT +0
2	3.0 (B)	0.0	QUANT STEPD VEXT LIMIT +2
...	...	0.0	QUANT STEPD VEXT LIMIT Any offset
16	7.0 (C)	0.0	QUANT STEPD VEXT LIMIT +4

If you have a source of programmed voltages (eq models 245, 246 or 251e) you can patch fixed voltages to each of the external inputs A through D, and use the random strobe to shuffle them. Use the octave transposition trick above to add additional range to the arpeggiation.

8x Envelopes with Random Velocities

Stage Address	
Patches	Trigger pulse → START SOU (any CV out) → EXTA VOUT → 292 level

Step	Volt	Time	Data
1	0.0 (A)	1.0	STEPD VEXT
2	0.0	1.0	SLOPD STOP
...	...	...	
15	0.0 (A)	1.0	STEPD VEXT
16	0.0	1.0	SLOPD STOP

This is a variation on the 8x envelopes patch that introduces a random amplitude/velocity element. Send the SOU output to the EXTA input and set some or all of the odd stages to VEXT mode. The amplitude of the envelope will now be varied by the SOU. Setting all steps to random will create even, random patterns. Setting one or two random steps on the off beat will add an unpredictable, syncopated element to the pattern.

Randomized Step Durations

Stage Address	
Patches	Trigger pulse → START SOU (any CV out) → EXTA VOUT → Any modulation destination

Step	Volt	Time	Data
1	1.0	5.0	STEPD STOP
2	2.0	0.0 (A)	STEPD STOP TEXT TIME3
...	*any*	...	STEPD STOP
15	3.0	5.0	STEPD STOP
16	4.0	5.0	STEPD STOP

The external time range mode can be used to randomly vary the duration of a stage, but the results can be erratic for rhythmic material. This patch keeps random modulations in time.

Set up the basic clocked follower patch and direct the voltage output to the modulation destination of your choice (pitch, timbre, etc.). Input the SOU voltage to the external input and set some stages into time range external (TIME3 TEXT) mode. Depending on the random voltage, those stages will overrun the clocking pulse and hold on that stage for longer. Once the stage comes to a stop, the next stage can start again on the next timing pulse. The effect is that the modulation will randomly hold for a number of beats, but always change in time with the clock pulse.

Maze Melody

Stage Address	STROB SEXT
Patches	Trigger pulse → STROB Trigger pulse → 266e (Stored random) update 266e (Stored random CV out) → SEXT VOUT → Pitch CV on 259, 261, etc TOUT → 266e (Stored random) skew in

Step	Volt	Time	Data
1	0.0	3.5	QUANT LIMIT +0
2	0.0	3.5	QUANT LIMIT +1
3	0.0	3.5	QUANT LIMIT +2
4	0.0	9.0	QUANT LIMIT +3
5	4.2	6.0	QUANT LIMIT +0
6	4.2	6.0	QUANT LIMIT +1
7	4.2	6.0	QUANT LIMIT +2
8	4.2	0.0	QUANT LIMIT +3
9	5.9	9.0	QUANT LIMIT +0
10	5.9	9.0	QUANT LIMIT +1
11	5.9	9.0	QUANT LIMIT +2
12	5.9	6.0	QUANT LIMIT +3
13	7.6	1.0	QUANT LIMIT +0
14	7.6	1.0	QUANT LIMIT +1
15	7.6	1.0	QUANT LIMIT +2
16	7.6	9.0	QUANT LIMIT +3

This follower patch creates a maze-like pattern that never repeats itself. The pitch voltages are programmed to a major seventh chord that spans four octaves. The AFG's TOUT is fed back into its own SEXT input, so that the position of each time slider determines the jump to the next step. This is fun, but the basic approach creates many infinite loops. So the TOUT cv instead goes through the 266e's stored random section, so that the next step is chosen with some additional randomness. The sequence will tend to ascend but jump around as well.

SUZANNE'S PATCHES

In 1976, Suzanne Ciani applied for a grant from the National Endowment for the Arts (NEA) and submitted a 24 page report illustrating in detail how she performed with her 200 system in those years. The essential ideas behind three patches that she describes in that report are included here, in a somewhat simplified form.

The full size patches that Suzanne described require a fairly large system to realize. Only three additional modules are absolutely necessary to replicate the patches shown here: the 266 Source of Uncertainty, a quad sequencer such as the current 251e, and a complex waveform generator such as the current 261e.

Prism Melody

Stage Address	STROB SEXT
Patches	Sequencer trigger pulse → STROB Pitch sequence → EXTA SOU (continuous random CV out) → SEXT VOUT → Pitch CV in on 259, 261, etc. TOUT → Timbre or waveshape CV in on 259, 261, etc.

Step	Volt	Time	Data
1	0.0 (A)	0.0	QUANT STEPD VEXT TIME1 LIMIT +0
2	0.0 (A)	0.0	QUANT STEPD VEXT TIME1 LIMIT +2
...	...	0.0	QUANT STEPD VEXT TIME1 LIMIT Any offset
16	0.0 (A)	0.0	QUANT STEPD VEXT TIME1 LIMIT +4

The prism melody patch combines elements of both the Random Timbre Modulation and Random Octave Transposition patches. As the stage address is driven by the sequencer pulse, the time sliders are free to provide a second modulation source, so that a single AFG section can affect both pitch and timbre. The VOUT provides a regular pitch sequence to the oscillator, but the random timbre and register changes create the illusion of multiple moving lines.

In the original paper, Suzanne shows one section of the AFG playing this type of part, against another section providing a simpler, more regular sequencer line that shares the same pulse.

Vertical Sequencer

Stage Address	
Patches	Pitch sequence → EXTA Pitch sequence → EXTB Pitch sequence → EXTC Pitch sequence → EXTD VOUT → Pitch CV in on 259, 261, etc. P2OUT → Sequencer advance input

Step	Volt	Time	Data
1	0.0 (A)	0.0	QUANT STEPD VEXT LIMIT +0
2	3.0 (B)	0.0	QUANT STEPD VEXT LIMIT +2
...	...	0.0	QUANT STEPD VEXT LIMIT Any offset
16	7.0 (C)	0.0	QUANT STEPD VEXT LIMIT +4 PULSE2

The remarkable vertical sequencer is Suzanne's invention. This patch is so versatile that it can almost serve as the basis for an entire performance, especially when run on both sections!

The vertical sequencer requires another quad sequencer module to be programmed with four distinct melodic lines, each fed to the external voltage inputs. The 1970's era patch used the monster model 246 analog sequencer, which provides a 16x4 matrix of 64 possible programmed voltages. A modern version utilizing the 251e can stretch out even further, supporting up to 50 steps on each section (*and recall!*). However, the vertical sequencer concept is powerful enough that even the modest 254 with its 5x4 matrix can be used to produce interesting results. Keep in mind that the limited range mode requires a 0-10v swing to make an octave, and you will have to scale the input voltages accordingly (roughly 8x).

The four sequencer sections' CV outputs are fed to external voltage inputs A-D. The effect of the program is that the four pitches at each stage of the sequencer are arpeggiated by the AFG, which then advances the sequencer to its next stage after completing each pattern. Think of it this way: the AFG scans the first column of the sequencer matrix up and down for the first 16 beats, then up and down the second column for the next 16, and so on.

Adjust the pattern of voltage sliders, and the octave offset switches until the part is to your liking. Keep all time sliders down at 0.0 to keep a regular rhythm, and adjust the speed of the arpeggiation with the time base knob.

You can run both sections as distinct vertical sequencers at the same time. Clock them together, or set them against each other to create a busy counterpoint. Finally keep in mind, that if you want to use the other section for a different application, you can shrink your vertical sequencer down to 12 or 8 steps just by setting a smaller cycle.

String Patch

Set both sections to the same settings, with the time base knob on AFG2 slightly faster.

Stage Address	STROB SEXT
Patches	Sequencer trigger pulse (very fast) → STROB SOU (continuous random CV out, very slow) → SEXT VOUT → Pitch CV in on 259, 261, etc.

Step	Volt	Time	Data
1	1.0	4.0	CONT SLOPD LIMIT TIME2
2	3.0	2.0	CONT SLOPD LIMIT TIME2
...	...	*any*	CONT SLOPD LIMIT TIME2
16	2.0	3.0	CONT SLOPD LIMIT TIME2

The String Patch is tricky to dial in, and requires some additional processing to actually sound like "strings". A very fast sequencer pulse strobes the stages around by a very slow moving random voltage. The two sections are set to a different time base, so that they each slew to the next stage at a slightly different speed causing the pitch of the two oscillators to separate just slightly.

Suzanne directed the two oscillators to each input of a frequency shifter to produce a "bowing" at each stage change, and further chose appropriate sawtooth waveforms and comb filter settings to produce a string-like sound.

If you're not very interested in making string sounds, you can also coax wild frequency-shifted swoops or ring-mod sounds from this patch with just a few tweaks. I personally haven't been successful creating anything remotely string-like with this patch yet, but every time I do try it leads to something else interesting, so don't take the name too literally!

Revision history

Feb 16, 2020	First draft.
Feb 18, 2020	Added Suzanne's patches.
Mar 03, 2020	Added sequencer section. New formatting and TOC.
Mar 24, 2020	Tested all patches. Removed sample and hold section, as it doesn't really work.
Mar 25, 2020	First public distro.