**RANDOM*SOURCE**

Ian Fritz CHAQUO
Chaos Generator (CG) + Quad Oscillator (QO)

The main function of this module is a versatile chaotic signal generator (CG). Chaotic signals are signals that have varying degrees of interesting irregularity without actually becoming random. This CG is an analog electronic simulation of the classical driven double potential-well problem, with the addition of extra gain in the circuit loop, and an extra cross-coupling path to extend the range of chaotic patterns available. The double-well system is a second-order system and therefore requires an external driving signal. This is provided by the second part of the module, a sinusoidal quadrature oscillator (QO). The two parts of the module may be used together or separately. The CG may be driven by any output of the built-in QO or by any external oscillator.

The QO may drive the CG or be used independently as a four phase oscillator for the usual spatial modulation and other applications. Both parts of the module are manually controlled, to provide a compact, cost-effective unit. The QO has a frequency span of ~0.03 Hz to ~3 kHz in two overlapping ranges.

The Random*Source CGAQUO kit consists of a main pcb and a matching component pcb serving as an interface to the front panel.

Main pcb:
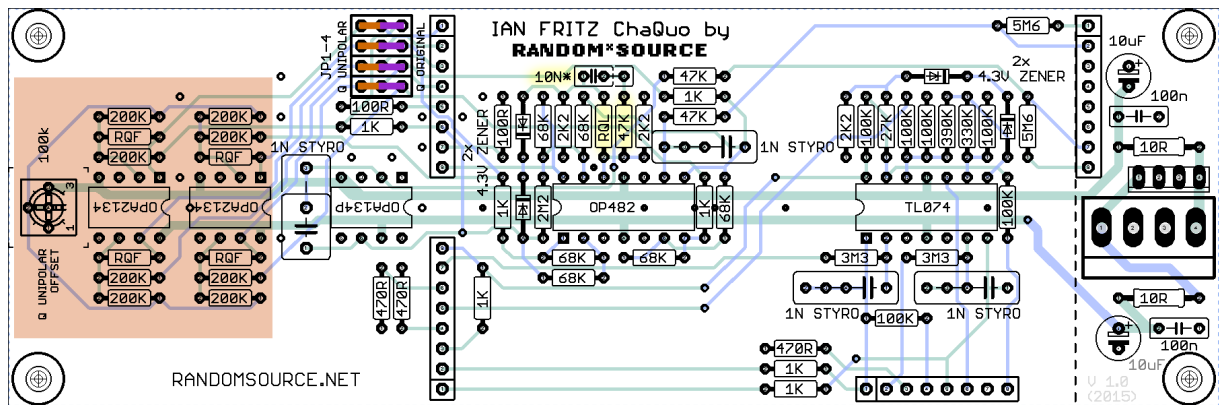
Please note:

- The **pot values for the (dual) COARSE and FINE pots should be 100K and 10K** - values indicated on component pcb are incorrect (they work also, but are not ideal).

- The main pcb contains the original Ian Fritz circuits (Chaos Generator and Quad Oscillator) plus **optional** circuitry (orange in the picture above) to buffer and scale the 4 sine outputs of the Quad Oscillator - e.g. to change their amplitude and/or add an offset to make them unipolar (0-5V).
To use the original sine outputs, the 4 purple **jumpers must be installed**. To use the buffered outputs, use the orange buffer positions.

- Use 1% (or even better: pairs of hand-matched) zener 4.3V min. 500mW diodes.

- The Quad Oscillator also contains an **optional** compensation network consisting of a 10N capacitor (marked "**10**" on the pcb - see highlighted yellow label above) - and the 47k resistor next to the resistor marked RQL. This network is probably not necessary (it may be used to compensate the Quad Osc amplitudes over frequency). Use at your own discretion, i.e. **do not install the capacitor unless you have a reason to do so (or want to experiment)**.

- Building the module - especially connecting main board, component pcb and front panel - is not particularly difficult, however, due to the stereo pots it's easier to make mistakes - please make sure you read the tips below before you start.

- Orientation of the main pcb: **power header is at the bottom** (when looking at the module upright, e.g. in a rack).

- Board is designed to be powered by a +/-12V stabilized PSU.

Bill of Materials

Resistors (1%)

2	10R	F1, F2	alt: ferrit beads
2	100R	R26Q, R33Q	
3	470R	R3C, R7C, R8C	
7	1k	R1C, R5C, R10C, R38Q, R40Q, R43Q, R45Q	
3	2k2	R20C, R35Q, R36Q	
1	27k	R19C	
1	RQL	R37Q	original value: 33k, use 27k to lower QO output amplitude
3	47k	R28Q, R31Q, R37B	
6	68k	R29Q, R34Q, R39Q, R41Q, R42Q, R44Q	
4	RQF	R14C3, R14C6, R14C9, R14C12	feedback resistors for optional output buffers (QO) - use 105k / adjust according to desired output level.
6	100k	R11C, R14C, R15C, R16C, R17C, R22C	
8	200k	R14C1, R14C2, R14C4, R14C5, R14C7, R14C8, R14C10, R14C11	for optional output buffers (QO) - see text
1	330k	R21C	
1	390k	R18C	
1	100K	QUAD-OFFSET	optional - Trimpot (3362 or anything that fits) to add DC offset to the buffered output

Capacitors

4	1N	C1, C2, C3, C4	Styrene or C0G/NPO
1	10N*	C5Q	optional conpensation network - see text - not 100N as marked on the pcb!

| 2 | 100n | C3P, C4P | Bypass caps |
| 2 | 10uF | C1, C2 | Electrolytic |

ICs

4	4.3V	D1C, D2C, D3Q, D4Q	1N5229 (or equivalent) 4.3 V Zener diodes - 1% or matched pairs, min. 500mW (DO35 package)
1	OP482	U2	Analog Devices
1	OPA134P	U3	Burr-Brown single op-amp
2	OPA2134	IC1, IC2	Burr-Brown dual op-amp
1	TL074	U1C	
3	1N4148	D1, D2, D3	

Misc

| 2 | Dual 100k pots | log preferred (A100K) - COARSE, RATE - USE 100K (NOT 1 M) FOR COARSE! - | Alpha 16mm Stereo pot - pcb mount - available from Banzai Music or Smallbear |
1	Dual 10k pot	linear or log (B10K or A10K) - FINE - USE 10K (NOT 100K) FOR FINE! -	Alpha 16mm Stereo pot - pcb mount - available from Banzai Music or Smallbear
4	Potentionmeter 100k	linear (B100K)	Alpha 9mm vertical pcb mount available from Thonk, Tayda
1	Switch	DPST or DPDT	NKK M2022SS1W01 (Myama 500 series should fit as well)
4	Jumper	JP1	QO JUMPERs must be set for oiginal output or buffered output
1	MTA-156		MTA-156 power connector
4	SIL header 8pol		8-pin connector, links main pcb to component pcb
8	Banana Jacks		Emerson-Johnson Thonk / Mouser: 530-108-0903-1 (black)
4	Potentionmeter 50k or 100k	linear (B50K or B100K)	Alpha 9mm vertical pcb mount available from Thonk, Tayda

Building and Module Assembly

This is simply a suggestion - you might find a different workflow more practical.

The module shares a component pcb with the Ian Fritz TGTSH - the following instructions and hints apply to the assembly of the entire module (including the TGTSH).

1.   Mount the Banana jacks, and the switch onto the front panel.

2.   Mount the pots onto the component pcb. Pots should sit on the printed side - this side faces the front panel. Don't solder them in yet!

3.   Carefully mount component pcb (with the pots inserted) onto the front panel. You may then have to wiggle each pot a bit to get the pots through. Make sure the threads of the pots go through completely and the pots sit right at the front panel. You can even screw the pots to the panel to

make sure of that, but you have to unscrew them again later (for Step 5). **Make sure the dual gang pots sit tight between the components pcb and the front panel** - there should be no room on either side(!) The height of the dual gang pots set the (minimum) distance between the front panel and the component pcb. As the dual gang pots are higher than the 9mm alpha pots, the 9mm pots should be aligned with the front panel - they will not sit on the component pcb(!) and their solder leads are just long enough so that they (barely) stick out of the component pcb. Unlike other RandomSource modules, the component pcb will not sit on top of the banana jacks, but there should be 2-3mm space:
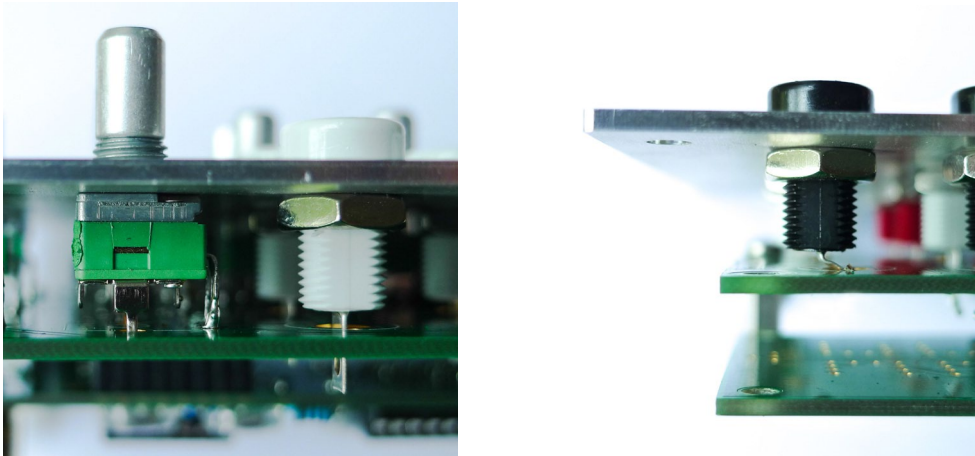
4. Also, please note that **the top two holes for the banana jacks on the component pcb are a bit off-grid** - to compensate for this unfortunate error, you have to bend the solder lugs of the banana jacks S-like as shown on the right picture above so that they fit into the holes (vias) again.

5. Once everything is nicely in place - and you have double-checked the position of the dual gang pots and the 9mm pots! - solder the the pots onto the component pcb (while the front panel is attached). As explained, the solder lugs of the 9mm alpha pots will pretty much align with the top of the pcb, i.e. not stick out. This is still enough to solder them properly in.
DO NOT SOLDER THE BANANA JACKS YET!

6. Solder short pieces of (stiff) wire - about 10mm long - into the pads for the switch. These should stick up in the air (on the side facing the main pcb). These wires should only go through the pcb as much as required to solder them in (i.e. should not stick out much on the other side, especially not touch the front panel or anything else!). DO NOT SOLDER THEM ONTO THE SWITCH YET! Remove the component pcb if you have not already done so.

7. Build the main board, beginning with the resistors, then caps etc.

8. Main pcb and component pcb are to be connected through precision DIP socket and pins. It is recommended to use the pins on the main pcb (facing down, soldered from above) and the pin sockets on the component pcb (standing up, soldered from the front panel side). Break or cut off the pieces you need and stick them together so that main pcb and component pcb form a nice sandwich (don't solder yet). Check that you didn't leave out any pins / holes and that the sockets are all on the same side (component pcb). Solder all the pins in while keeping the sandwich to-

gether - this avoids any misalignments.

9.   Carefully separate the sandwich - if you used precision sockets, this may not to too easy - they stick together nicely (giving a good connection).

10.   Mount the component pcb onto the front panel again and screw on the pots from the front side.

11.   Make sure everything is in place.

12.   Solder the banana jacks in. You can either solder them directly to the surrounding vias (the ring around) or - which makes removing easier should you ever need to do that - by inserting a stiff (bare) wire into the little hole (via) and solder that wire to the top of the banana jack:
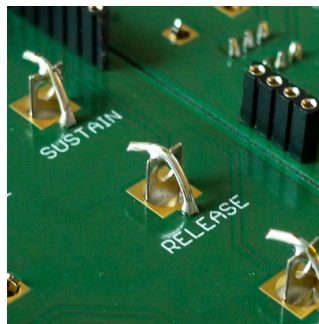
13.   Attach any screws / spacers if desired and mount the main pcb onto the component pcb.

14.   Connect a power cord supplying +12V, GND, GND, -12V to the MTA-header on the main board and you should be ready to go :-)

Setup and Operation

There are no calibration or other adjustments for these circuits.

The output levels of the QO are between 4 V and 6 V, depending on frequency. The variation is mainly due to imperfect tracking of the dual pots. The signal may be checked on an oscilloscope or by ear. On the high-frequency range the signal should span about 3 Hz to 3 kHz, and it should look and sound like a high-purity sine wave. On the low-frequency range the signal should span about 0.03 Hz (33 sec period) to 30 Hz. Operation may be verified on a scope or by using the signal to modulate a VCO. Correct quadrature phases may be verified with a dual-trace scope.

One warning: the QO takes about 30 cycles to stabilize upon power up. So if you turn it on and it doesn't seem to be running, just turn it up to a higher frequency to get it going, and they back down if you want. Once started it follows changes quite well.

The chaos generator has a large number of unfamiliar controls, and not all setting of these controls will give oscillations. But with a systematic approach the user can quickly learn the basics of operating the unit. It's easiest to do this with a scope, especially if it can make Lissajou patterns, but it can also be done by ear. The best place to start, especially if learning by ear, is to think of the CG as a complex kind of LFO. So start

out by hooking up the X and/or Y outputs to the FM inputs of some VCOs/VCFs/etc., set to a comfortable audio signal.

This particular CG requires an external drive signal to produce chaotic oscillations. The driving signal may be the QO or any other oscillator. For now just connect any QO output to the Drive In (This connection may already be normed, depending on the panel design.) Set the Drive Level at 50% of full scale (FS) to start.

Two of the controls may be thought of as advanced controls, and for now should be set at special positions and left there. These are the Coupling control -- set to zero -- and the Gain control -- set to 1/3 FS. (With these settings, the CG is the same as the EZChaos circuit, which many users will already be familiar with.)

Next set the Rate control at 50% FS. This control is analagous to the frequency control of an LFO or VCO.

The higher the Rate, the faster the system will run, everything else being equal.

Next set the Damping control to 30% FS. Damping can be thought of as the opposite of resonance in a filter. The less the damping the "wilder" the chaos gets and vice versa.

Now you are set to look for the chaotic regions of the system! You will do this by varying the frequency of the driving oscillator. Start at a fairly high frequency and tune it downward until you start to hear a modulation of your audio patch. On the scope look for a small oval to appear. At this point, the CG is executing nearly sinusoidal oscillations. Continue lowering the drive frequency (slowly) and you will hear the modulation become slower and deeper until you reach a point where the modulated signal becomes irregular and jittery. You're there! That's what chaotic control sounds like.

Continue to decrease the drive frequency slowly and you will hear several regions of regular (periodic) and irregular (chaotic) oscillations. Eventually you will reach an end point where the signal is regularly bouncing between two regions. On the scope this looks like a kind of double spiral.

From here experiment with the effects of all the controls, one at a time. Tune back into the chaotic region and look at how the signal varies as you change either the drive level or the damping. Remember, if you get lost, you can always get back to a base position by following the procedure above.

The Gain and Coupling controls can be explored when you have a good feel for the other controls. Try changing the Gain first and see how it changes the patterns you got before. Finally you can start turning the Coupling control up. This adds another signal path to the system and can easily get out of control. As you increase the Coupling you generally need to increase the Gain to keep the system from running to the rails. Another "minor" detail is that with the Coupling turned up, the system can self oscillate, i.e. it does not need the drive signal to oscillate. These will not be chaotic oscillations, but still quite interesting, especially when you are in a region where both the self oscillations and the driven ones are competing.

From here you are on your own to explore the many uses of the system for modulation, statickey audio effects and so on. Also very important is the use of the chaotic signals to define chaotic timing events, to feed through S/H modules, and for other non-continuous applications.

(Version 31 July 2015)