Oakley Sound Systems
‘Basic Series’
Dual AD/AR Envelope Generator

User’s Guide

Tony Allgood B.Eng
Oakley Sound Systems
PENRITH
CA10 1HR
United Kingdom

e-mail: oakley@techrepairs.freeserve.co.uk

Introduction

This is a simple but effective envelope generator module primarily designed for use in modular synthesisers. Its basic design and the use of PCB mounted pots makes this an ideal starter module for beginners to my modular synthesiser projects.

The envelope generator or EG for short, generates a rising and falling voltage at it's output when triggered by a gate signal. The gate is derived from a keyboard, switch or a midi-CV convertor elsewhere in the synthesiser system. The speed of the rise in output voltage is determined by the Attack control. The speed of the fall of the output voltage is determined by the Decay or Release controls. The output of an EG is traditionally patched to the VCA control voltage, to control the volume of the note when the keyboard is pressed, or to the VCF, where it dynamically alters the harmonic structure of the sound throughout the duration of the note played.

Traditionally there are three basic analogue EG types available: attack-decay (AD), attack-release (AR), and attack-decay-sustain-release (ADSR). Other types are available, especially on digital synthesisers, but the three analogue types still seem to the most musician friendly.

The AD type produces a rising voltage in the attack phase. This rises exponentially from zero until a predetermined value is reached. The decay phase then starts where the output voltage falls back to zero. If the gate is removed during the attack phase, the decay is prematurely started and the voltage output will fall without the peak ever being attained. Two pots are required for the control of an AD type EG.

The AR type produces a rising voltage in the attack phase, again rising exponentially, to the sustain level. The voltage will then remain at this level for as long as the gate is held high. When the gate is removed, the output will fall back to zero. This is the final release stage. Again, only two pots are needed for an AR-EG.

The ADSR type is controlled by four pots. The attack phase is initiated by the gate signal, the output will rise to a predetermined level, whereupon the decay phase takes place. However, the output voltage will fall to the level set by the sustain pot. It will stay there until the gate is removed, when the final release stage is initiated.

The ADSR-EG can perform both AR and AD operations simply by turning the sustain pot full up or down respectively. It is this that has made the ADSR the most common type of EG within a synthesiser. However, it of my opinion that this is over engineering the EG. Two simple types are better than one ADSR.

The Juno-6 and its followers were severely hampered by just one ADSR. The MicroMoog had just two simple EGs and performed much better. Each of its EGs can be switched to be AD or AR and I was amazed that this did not really affect its sound palette in any major way. My other homemade synths have full ADSRs, but on reflection, I rarely use the sustain pot properly. For the VCA, I normally set the sustain pot full up. For the VCF, I normally set the sustain at minimum. Sometimes, it is true, a certain sound does demand use of the full ADSR, but there are other ways around this.

So with the help of Steve Ridley, I had a rethink for my new EG design. My new EG would be able to produce AD and AR simultaneously, so no need for a switch here. The unit could be wired up to have two pots, so that attack and decay/release phases could be controlled together for the both types of EG output. Or, you could have four pots to control the AD and AR parts separately, although both would be triggered by the same gate.

Many traditional synth patches could be realised with just one EG with just two pots. You could fit three such EGs in one 2U wide MOTM style panel. This is what I have done for my triple Basic EG. See later for more details.

If you went for the four pot version you could fit one EG into one 1U wide panel. If you used both outputs and mixed them together, you could get ADSR if you wished, but you could get much more. Imagine a sound that quickly swells up and falls, only to be built up again and held with sustain. I soon began to realise that this module was more useful in a modular set up than a single ADSR-EG.

All the parts are easily obtainable, although the PCB mounted pots and pot brackets are available from me should you find any difficulty in getting these.

The PCB

The PCB is small and almost cute at just 7.3 x 5.7cm in size. It uses double sided copper traces and has through plated holes. It has solder mask both sides for easier soldering, and has component legending on the top side for easier building.

I have provided space for the two control pots on the PCB. These can be mounted away from the PCB, but they do form part of the mounting process, as no holes are provided on the PCB for supporting the board. If you use the specified pots and brackets, the PCB can be held very firmly to the front panel. The pot spacing is 1.625" and is the same as MOTM modular synthesiser. The board is fully MOTM panel compatible if the board is fitted horizontally, ie. in a 2U wide panel. The standard design is to use two dual ganged pots and have the time constants of the AD and AR outputs linked. I have included a suggested front panel layout at the back of this document.

If you choose to have a four pot design, that is separate attack and decay pots for the AD and AR outputs, you use single 1M pots. You will only mount two of the pots to the PCB, the AR ones, and the other two will have to be connected by pieces of flexible wire. If you are mounting the board vertically to go into a 1U MOTM panel, make sure the two board mounted pots are the bottom pair of pots to avoid fouling the MOTM rails.

The design requires plus and minus 15V supplies. These should be adequately regulated. The current consumption is about 30mA per rail. Power is routed onto the PCB by a four way 0.1" header. You could, of course, wire up the board by soldering on wires directly. The four pins are +15V, ground, earth, -15V. The earth connection allows you to connect the metal front panel to the power supply's ground without it sharing the modules' ground line. More about this later. The connector used is different to my other larger module designs. The reason for this was to keep board space at a minimum. The current drawn by this module is very small, and 0.1" headers are very reliable at this level. Performance will not be impaired. Also the use of smaller connectors, aids the fitting of multiple boards in one modular panel.

Circuit Description

The EG circuit is quite simple, but let's run through the design carefully. Looking at the left of the schematic you can see the four way header, labeled SPLY. Power enters the board here, and is immediately filtered by a simple RC networks based around R99 and C34 for the positive rail, and R98 and C33 for the negative rail. Two grounds are provided, one for the circuit itself, and one for the earthing of the jack sockets on the front panel.

There are just two ICs on this PCB, and each requires power. The power supplies to each IC is shown separately to avoid cluttering the main circuit diagram. Note that the TL072 requires both negative and positive supplies, while the LM556 requires only a single supply. However, the supply to the LM556 is heavily decoupled and roughly regulated. R97 provides the current to keep C32 'topped up' with voltage. The zener diode, D9, limits this voltage to a maximum of 8.2V. When the output of the LM556 changes state the device shorts out its own power supply for a very short length of time. This can cause all sorts of problems if it is not catered for. C32, provides the LM556 with a very large reservoir of current, and R97 effectively isolates it from the main +15V supply. The zener diode is chosen so that the maximum output of the EG is set at around 5V. This is a bit crude, but it works well enough.

A gate signal is a control voltage that simply goes from zero, when inactive, to a higher voltage when active. Typically the gate signal will rise to +5V or higher. The gate is normally derived from a keyboard or a midi-CV convertor. The midi-DAC puts out a +5V gate as standard. A positive voltage at the gate input will turn on Q10, and take its collector down to about zero volts. Q8 will then be turned off and its collector dragged up to 8.2V by R95. This positive going signal is a copy of the input gate signal, but it has been conditioned so that the following circuits will be able to use it. C31 differentiates this signal to cause Q7 to briefly switch on, puling its collector down to ground for a very short while. This is the trigger pulse that activates the main timer IC, the LM556.

The key to understanding this EG is to understand the operation of the LM556. This is a dual timer, and is in fact, two of the ubiquitous LM555 timers in one package. The topper most half of the LM556 is concerned with generating the AD output. This is the output that will rise to a certain level at a rate determined by the attack, A1, pot and then falls back to zero at a speed governed by the decay pot.

When the falling-edge of the trigger signal is received by the LM556 at pin 8, the output at pin 9 will rise rapidly to the IC's supply rail, namely 8.2V. Current will flow from this pin via D6 and through A1 into the timing capacitor, C27. The voltage across C27 will rise, quickly at first, then getting slower. The overall rate of increase will be determined by A1 and R80. R80 is set so as not to cause excess current flowing from pin 9 and damaging the LM556. One half of the FET op-amp, TL072, sniffs at the voltage on the capacitor and its output follows this voltage precisely. The op-amp's output is the AD output we want, but it is also fed back into the timer IC at its threshold pin, pin 12. When pin 12 reaches two thirds of its supply voltage, about +5V, it will do two things. Firstly, pin 9 will go low, and current no longer flows through A1 into C27. The attack phase is now over. Secondly, the discharge pin, pin 13, is rapidly dragged down to zero volts. The decay pot is connected to pin 13 and so current now flows from C27 through the decay pot to ground. The voltage across C27 will fall, and the op-amp's output will follow this fall. D6 prevents any current from leaking into the now low pin 9 output. When the voltage finally approaches zero, our AD output cycle is now complete.

If at any time in this cycle the gate signal is removed, the reset pin, pin 10, will detect this and the discharge phase is invoked prematurely.

The AR output is generated in a similar to the AD, but there are some crucial differences. We wil look at these later, let us first consider what happens in an ordinary AR-EG, because mine is different. Normal AR-EGs produce a rising attack phase that levels off at the sustain voltage. This is normally set by the voltage at the ‘hot’ end of the attack pot. In other words the asymptote of the charging curve. However, in theory, the capacitor never actually gets there, just tends to that value. What this means is that the voltage is still rising after a considerable time. When this sort of EG is used to drive a VCA, the output lacks the punch needed in fast attack sounds. My EG is different and in some ways is more similar to a full ADSR. I use a 8.2V charging voltage, but enable the sustain portion of the signal when the output rises to just 5V. This gives a clean definable attack portion, and also allows the AR envelope to follow the AD output.

The LM556 is triggered with a sharp pulse at pin 6, the attack phase begins as before, with C28 charging through A2 and R82. When the threshold is reached, at around +5V, charging stops. However, C28 is not discharged while the gate remains high. Instead is kept ‘topped up’ to the threshold voltage. The threshold voltage is set inside the LM556 by three identical resistors. We cannot change these resistors, but we do have access to the junction of the top two at pin 3. The voltage at this point sets the threshold voltage to the 556’s internal comparator. We use the discharge output, pin 2, to control the base of Q5. It is not used to actually discharge the timing capacitor. When the base of Q5 is pulled low, the threshold voltage at pin 3 is passed via R84 and the release pot to C28. This keeps C28 at the threshold voltage during the time that gate is active but not during the attack phase. I think this is the first time that this technique has been used. When the gate is removed, Q6 turns on, and C28 is discharged to ground via the release pot.

In practice, the rather high output resistance, about 4K, of pin 3 creates a rather strange dip and rise in the output waveform when the sustain portion is initiated. However, it is a small perturbation, and is not audible in VCF or VCA applications.

A LED may be fitted to indicate the state of the gate input. Q9 performs the required switching operation. R96 is set to give roughly 4 ma of LED forward current. You can reduce the value of R96 if you wish your LEDs to be brighter.

Final point, you may be wondering why the component values start from high numbers and not from R1, C1 etc. This is because to keep the cost of this board down, I fitted the EG PCB layout onto the same EDWin database as the VCO and VCA projects. This way, only one set of photoplots was created for the three boards, and only one set of tooling costs were incurred. So you, dear customer, didn’t have to pay too much for the boards.

Components

All the parts are easily available form your local parts stockist. I use Maplin and Farnell, here in the UK. In North America, companies called Mouser, Newark and Digikey are very popular.

The pots are Omeg Eco types with matching brackets. You could use any type you want, but not all pots have the same pin spacing. Not a problem, of course, if you are not fitting them to the board. In the UK, Maplin and Rapid Electronic sell the Omeg pots at a very good price. Omeg will also sell direct, but this is only viable for large orders. All three have web sites. The values recommended are 1M log. You will be ill-advised to get linear pots, these make adjusting the rates very difficult at the fast end. For the two pot version of the Basic EG we need to make a few changes. 1M log dual gang pots are impossible to get hold of via Maplin and Rapid, although Omeg will make you some for a price. So I am supplying **470K log** ones instead for the two pot version only. This will reduce the maximum attack and decay time to about 5 seconds. So to compensate, my recommendation is to use a 15uF, 25V capacitor for C27 and 28. You can reduce R80 and 82 to 56R as well. If this EG design starts to sell in large numbers I will negotiate to buy a quantity of 1M log dual gang pots from Omeg. Check the prices page on my web site for any details.

I would go for 1% 0.25W metal film resistors throughout, but you could use 5% types with no problem.

For the capacitors, there are no set rules of type. All the electrolytics and tantalums should be radially mounted. The pitch spacing of the ceramic capacitor, C31, is 0.2”. While the pitch spacing of the polyester layer capacitors, C29 and 30, is 0.3”. I like the open frame Siemens polyester layer types.

Please be careful with the orientation of the polarised capacitors, diodes, LED and the transistors. **Please note:** The TL072 and the LM556 have pin 1 at the **top** left hand. The LED is connected so that it’s cathode is connected to pin 1 of the LED connector. Pin 1 is depicted on the board by a square pad for both ICs and the LED.

Paul Schreiber of SynthTech has won me over to water washable flux in solder. The quality of results is remarkable. In Europe, Farnell sell Multicore’s Hydro-X, a very good value water based product. You must wash the PCB at least once an hour while building, but the end result is worth the extra hassle. You will end up with bright sparkling PCBs with no mess, and no fear of moisture build up which afflicts rosin based flux. Most components can be washed in water, although, it is probably not a good idea to wash a board with trimmers and pots on. These can be soldered in after the final wash with conventional solder or the new type ‘no-clean’ solder.

The PCB has been laid out to accept 0.1” headers for all the interconnects including the power supply. Pin 1 is depicted by the square pin. For a modular setup, it is probably best to solder wires into the pads. The gate input is on a 2-pin header, pin 1 of which is connected to ground. This can be used for normalising your jacks, or for providing screening. See later for more details.

Finally, if you make a circuit change that makes the circuit better, do tell me so I can pass it on to others. Any updates are added to the current user guide, and posted on the ‘Mods’ page on my web site.

Parts List

The components are grouped into values, the order of the component names is of no particular consequence.

Resistors: all 1% metal film

22R	R98, 99
100R (56R See text)	R80, 82
390R	R97
1K	R79, 81
3K3	R96
10K	R94, 95
22K	R86, 89
100K	R84, 87, 88, 90, 91, 92, 93
220K	R85
1M	R83

Capacitors

22uF,25V elect	C33, 34
470uF,25V elect	C32
100pF ceramic	C31
100n polylayer	C29, 30
10uF, 16V tant	C27, 28 **For four pot version**
15uF, 16V tant	C27, 28 **For two pot version**

Discrete Semiconductors

1N4148	D8
1N4001	D6, D7
8.2V, 500mW zener	D9
BC550	Q6, 7, 8, 9, 10
BC560	Q5
LED (any colour)	(1 off)

Integrated Circuits

TL072 dual FET op-amp
LM556 dual 555 timer

Miscellaneous

4-way 0.1” lockable header	PWR
Pot bracket for Eco pots	(2 off)
1M log Eco pot	(4 off) **For four pot version**
470K log dual gang Eco pot	(2 off) **For two pot version**

You may well want to use sockets for the ICs. I would recommend low profile turned pin types as these are the most reliable.

Mounting the Pots

If you are using the recommended Eco pots, then they can support the PCB with specially manufactured pot brackets. You will not normally need any further support for the board. When constructing the board, fit the pot brackets to the pots by the nuts and washers supplied with the pots. But only solder the three pins that connect to the pot. Do not solder the pot bracket at this stage. When you have completed the PCB, you can fit it to your front panel. Position the PCB at right angles to the panel. Now you can solder each of the brackets. This will give you a very strong support and not stress the pot connections.

Connections

The power socket is 0.1” 4-way header. Friction lock types are recommended.

Power	***Pin number***
+15V	1
Module 0V	2
Earth/Screen	3
-15V	4

The SCRN pad on the PCB has been provided to allow the ground tags of the jack sockets to be connected to the power supply ground without using the modules 0V supply. Earth loops cannot occur through patch leads this way, although screening is maintained. Of course, this can only work if all your modules follow this principle. The SuperLadder does not do this, and the midiDAC has a need for two separate grounds anyway. However, I am planning to have all my new modules to fit this standard. It will be still compatible with the MOTM systems, although they use the larger 0.156” Molex connectors.

The board has only one input, which is the gate. Pin 1 is connected to ground should you need to use screened cable. With my triple EG panel, I have normalised two of the EGs to the gate of the other. This way, connecting gate to the top EG only, activates all three EGs.

The two outputs are labeled as AR and AD. Pin 2 is the relevant output for each 2-way header. The square pad, pin 1, is connected to local ground.

At the rear of this user guide I have included a 1:1 drawing of the suggested front panel layout for a triple EG panel. This, as the name suggests, contains three EG PCBs. The pots on each board hold the PCB firmly to the front panel. Power can be supplied to each one individually, or just to one of them, and then routed by three wires to the other two PCBs. The nine jacks are wired up by small pieces of insulated wire. Colour coding the wires makes it easy to connect, and gives an attractive finish.

Actual panels can be obtained from Schaeffer-Apparatebau of Berlin, Germany. The cost is about £25 per panel. All you need to do is e-mail the fpd file that is found on the EG web page on my site to Schaeffer, and they do the rest. The panel is black with white engraved legending. The panel itself is made from 2.5 mm thick anodised aluminium. The fpd panel can be edited with the Frontplatten Designer program available on the Schaeffer web site. Please note, the mounting holes are not compatible with the MOTM mounting rails. However, it should be a simple matter to alter these as required.

Final Comments

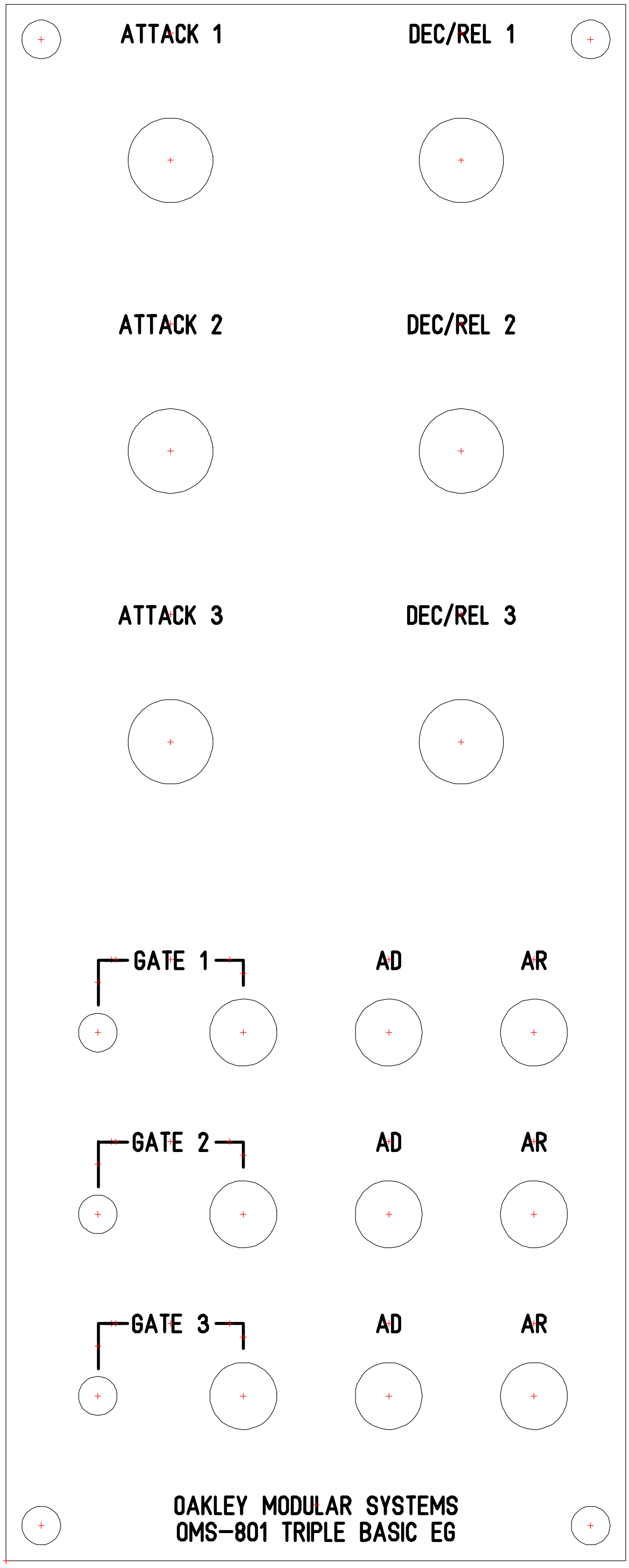
I hope you enjoy building the 'Basic Series' EG. Please feel free to ask any further questions about construction or setting up. If you cannot get your project to work, do get in touch with me, and I wil see what I can do. Sometimes, it can be the simplest things that can lay out a project. Occasionally, there may be an error in the parts list. I have checked the documentation again and again, but experience has taught me to expect some little error to creep past. The schematic is always the correct version, since the parts list is taken from the schematic. So if there is any problem, use the schematic as the guide. If you do notice any error, please get in touch. You will be credited on the 'Updates and Mods' page, and you may get a free PCB.

Please further any comments and questions back to me, and if you have any suggestions for new projects, feel free to contact me. You can e-mail, write or telephone me. If you telephone then it is best to do this on Monday to Wednesday, between 9 am and 6 pm, British time.

Tony Allgood. July 2000

Version. 1.03

Formatted on Lotus Word Pro


ATTACK 1
DEC/REL 1
ATTACK 2
DEC/REL 2
ATTACK 3
DEC/REL 3
GATE 1
AD
AR
GATE 2
AD
AR
GATE 3
AD
AR
OAKLEY MODULAR SYSTEMS
OMS-801 TRIPLE BASIC EG