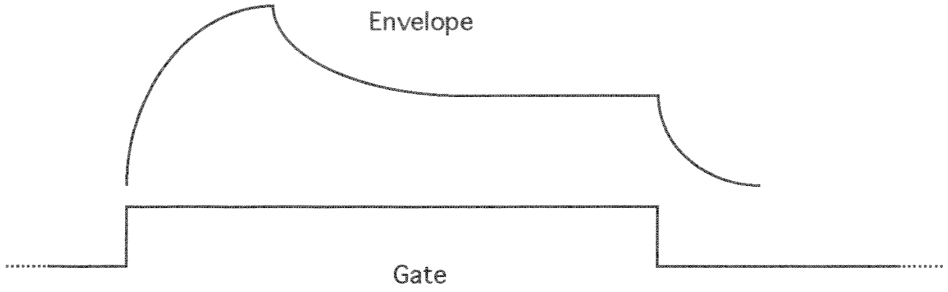
ADSR Envelope & Gate Signals

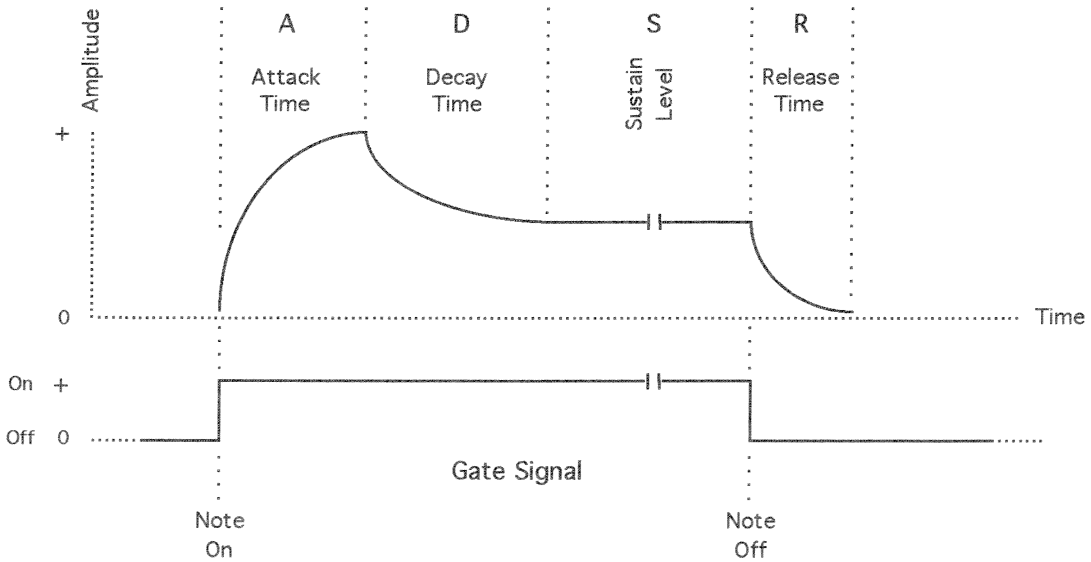
An *Envelope Signal* is a unipolar positive, aperiodic, subsonic, segmented, timed signal. In analog terms, an envelope signal may be thought of as fluctuating DC. A *Gate Signal* is a *two state* signal used to "gate," or start Envelope Generator (EG) circuitry. *Gate On* starts the *first* Envelope Signal segment; *Gate Off* starts the *last* segment of the Envelope Signal.



The classic ADSR four segment Envelope Generator (EG) provides independent control over *four* parameters: *three* times (Attack, Decay, and Release); and *one* level (Sustain). On receiving a *Gate On,* the EG signal output starts at *zero* level and rises to an internally fixed *maximum* level in the time determined by *Attack.* Level then goes from max to the programmed *Sustain Level* in the time determined by *Decay.* The programmed *Sustain Level* may be held as long as the *Gate* signal is *On.* At *Gate Off,* the EG signal returns to zero level in the time determined by *Release.*

In the case of modern Envelope Generators, *all levels* may be programmable, including both the "initial" and "maximum" levels shown in the case of the ADSR. It is important to understand that change(s) of *level(s)* in the *ADSR,* or in any such *time-based Envelope Generator* do *not* cause changes of segment *times* as set by the user. The *slope,* or *rate* at which a segment moves between levels *will* change as level(s) are altered, but *programmed times will not be affected.*

ADSR Envelope Signal

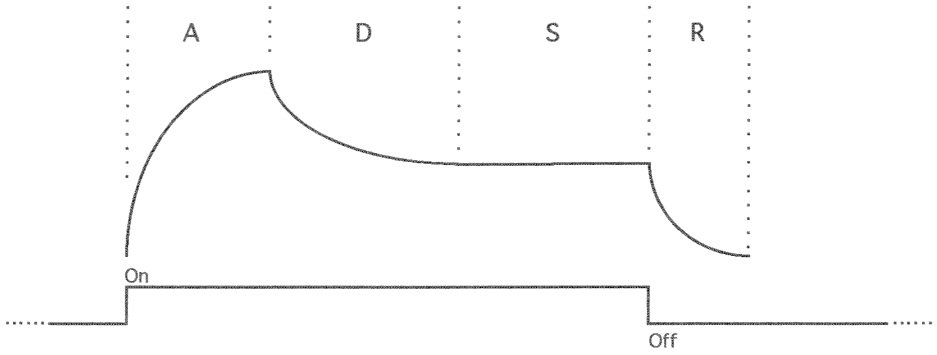


The typical source for the *Gate Signal* is the *Gate* or *Trigger Output* of a keyboard. The modern convention for the *Gate Signal* features *"On"* as the *higher* of two signal states, a "V-Trigger" (Voltage-Trigger) in older analog terms. The Gate On polarity (± sense) could be inverted, known formerly as an "S-Trigger" (Switch Trigger, or Switch to Ground). MIDI *note on/note off* is simply an 8-bit digitally encoded data word variant of the Gate Signal; MIDI functions similarly.

Each timed segment (Attack, Decay, or Release) of the ADSR might be thought of as a "rubber band" whose *slope* stretches between two levels as a *single* level or segment time is changed. The "Gallery of Graphics" below illustrates nonverbally how *successive* changes of a *single* level or segment time will interact with other segments to alter the envelope signal shape, as *Gate On* time is held *constant*. Study each possible *vertical pairing* of graphics below. (Comments follow).

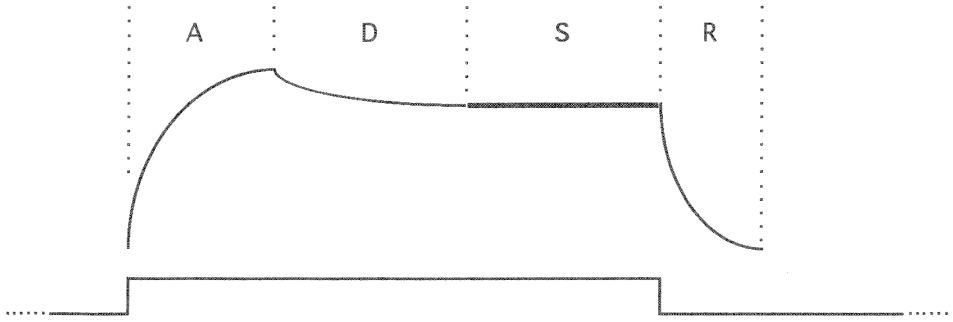
1.1

ADSR/Gate: Reference Diagram



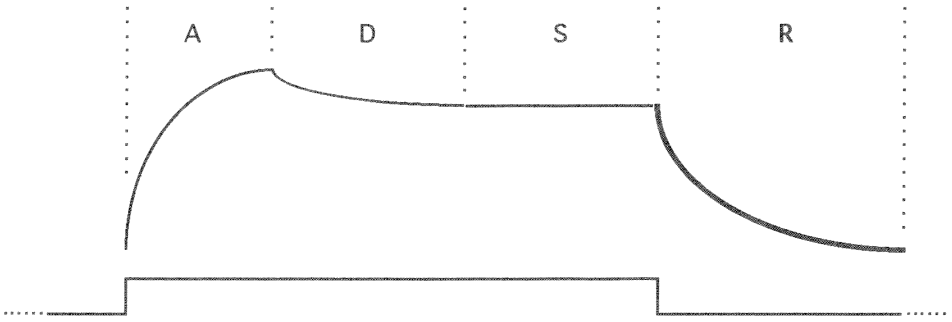
1.2

ADSR: Sustain Level Raised



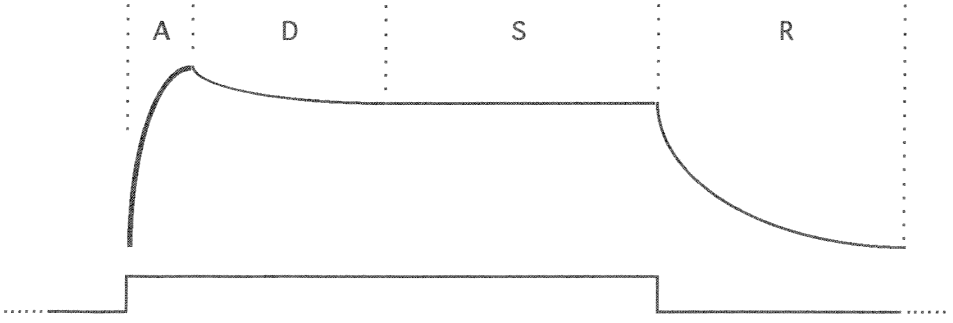
1.3

ADSR: Release Time Increased

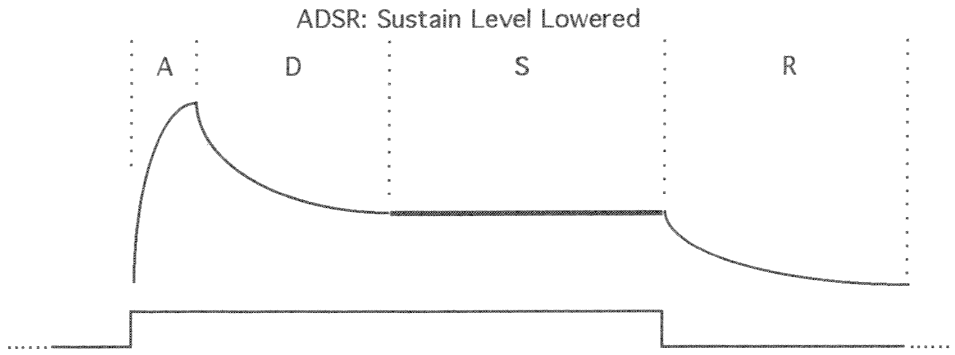


1.4

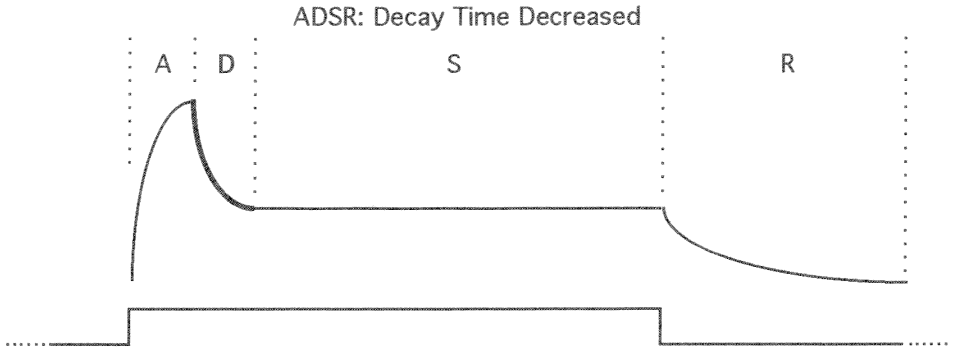
ADSR: Attack Time Decreased



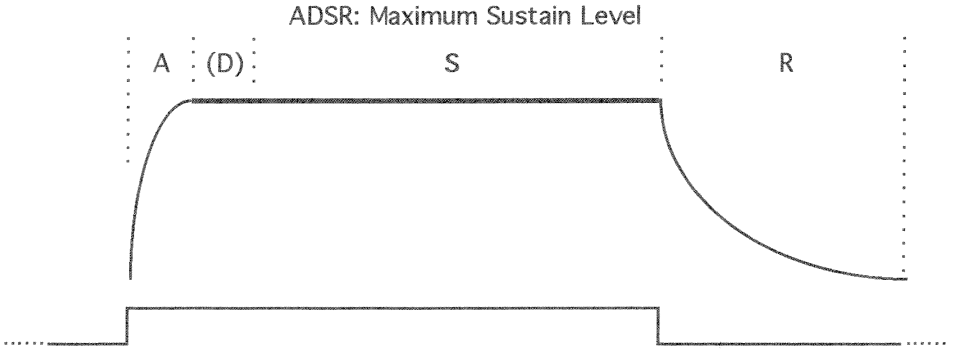
1.5



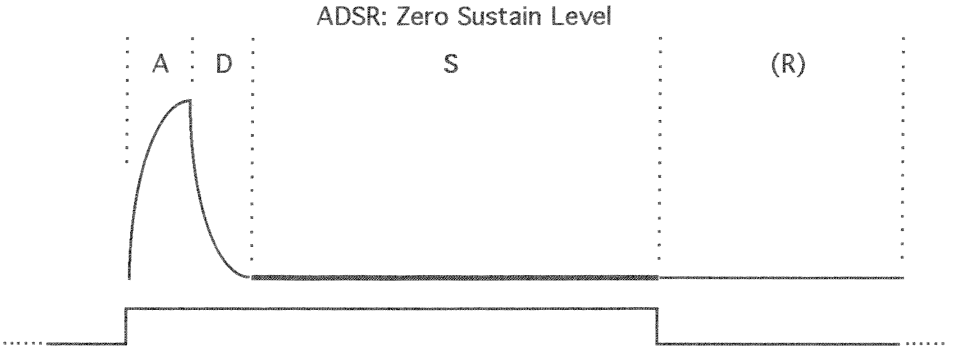
1.6



1.7

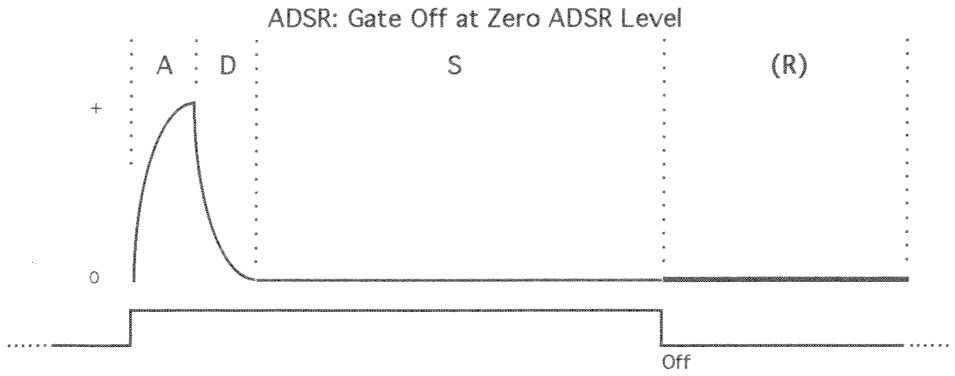


1.8

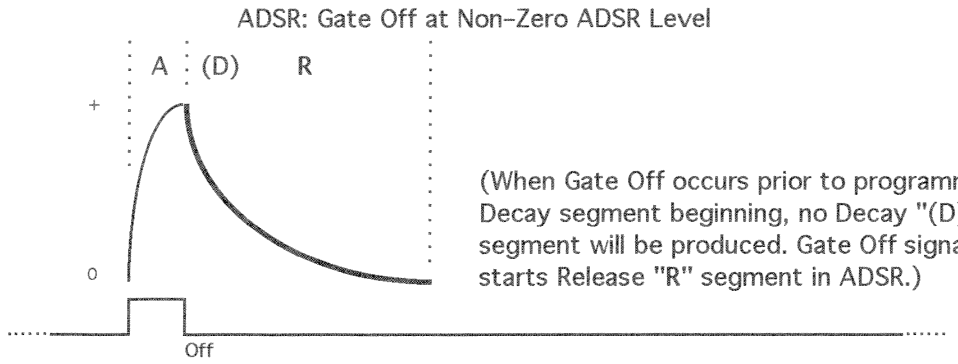


Gallery figures # 1.1--1.8: (1.1) Reference starting envelope. (1.2) S level increased, so D *rate decreased* & R *rate increased.* No change of times! (1.3) R time increased, so R *rate decreased.* (1.4) A time decreased, so A *rate increased.* D segment moves "forward" in time & S segment occupies more time due to constant Gate Off time in these examples. S segment has no programmed timing element! (1.5) S level decreased, so D *rate increased* & R *rate decreased.* No change of segment times due to level changes! (1.6) D time decreased, so D *rate increased.* S segment occupies more of total Gate On time. S is a level only, its time element depends on Gate Off! (1.7) S at maximum, so D time is not reflected in actual envelope shape. S segment "time" appears to increase. (1.8) S at zero, so D *rate increased,* D time unchanged! S level of zero implies that programming of R time is irrelevant, but this is so only when Gate Off occurs *after* D segment is finished. See Figure 1.9 below:

1.8.1



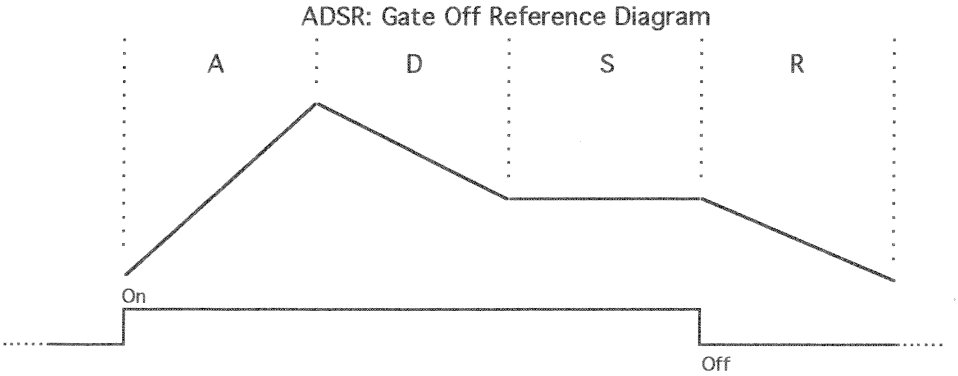
1.9



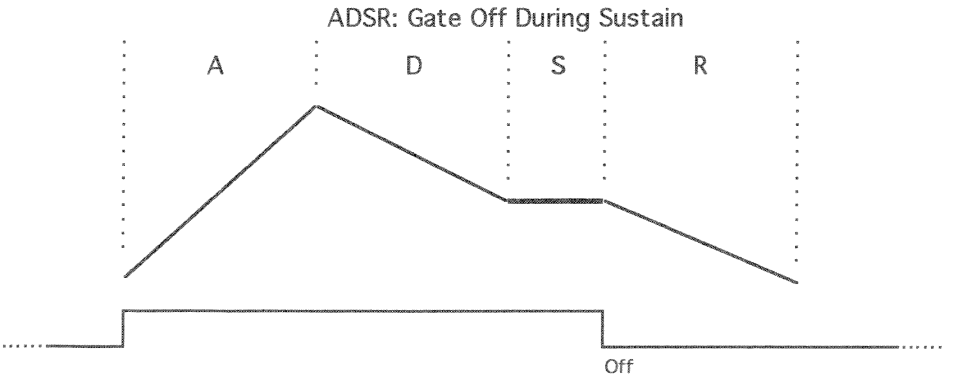
(When Gate Off occurs prior to programmed Decay segment beginning, no Decay "(D)" segment will be produced. Gate Off signal starts Release "R" segment in ADSR.)

Compare the two graphics above. Gate Off starts the Release segment, which will *fall* toward zero level if envelope signal level is *positive* at the instant of Gate Off. The Gallery of Graphics below portrays A, D, and R times of 1 second and a 3 second *Gate On*. Envelope segments are shown as straight lines for graphic clarity. Study the ADSR signal change as Gate Off occurs at successively earlier times *as all ADSR times and levels are held constant.* Comments follow.

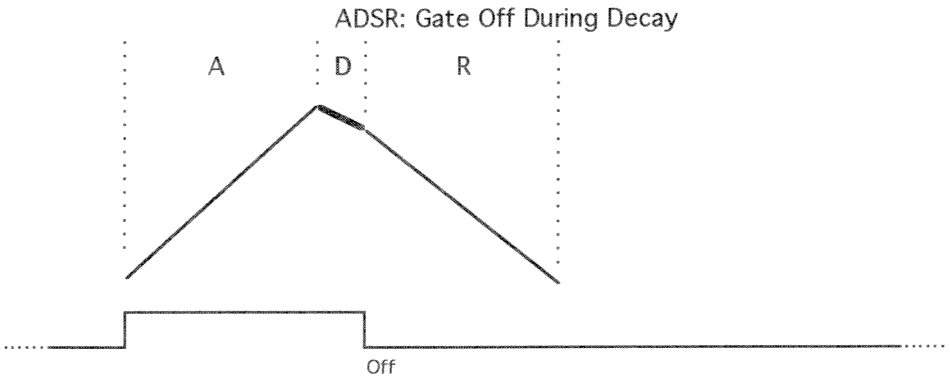
2.0



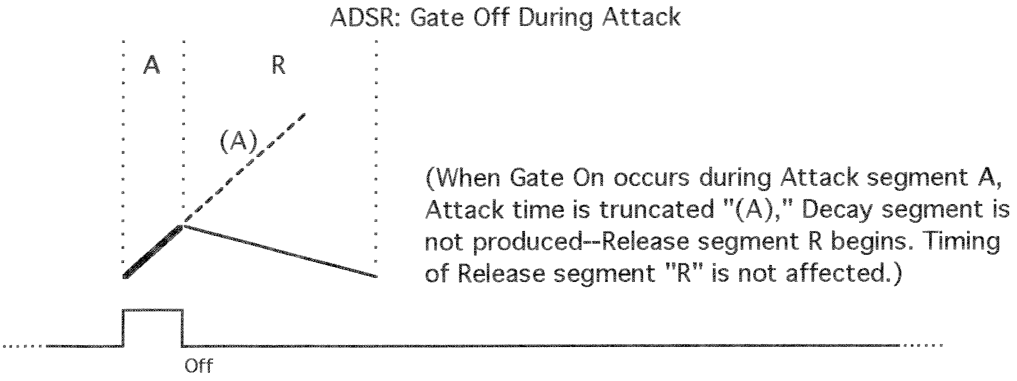
2.1



2.2

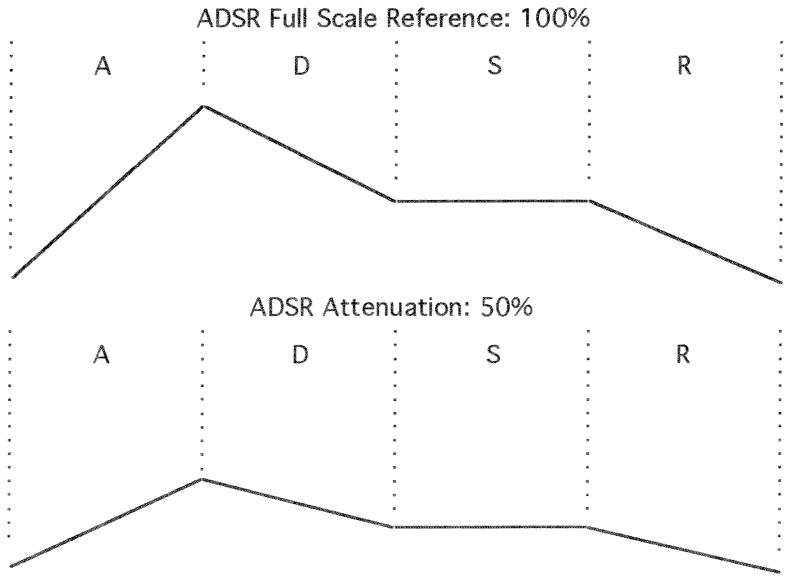


2.3

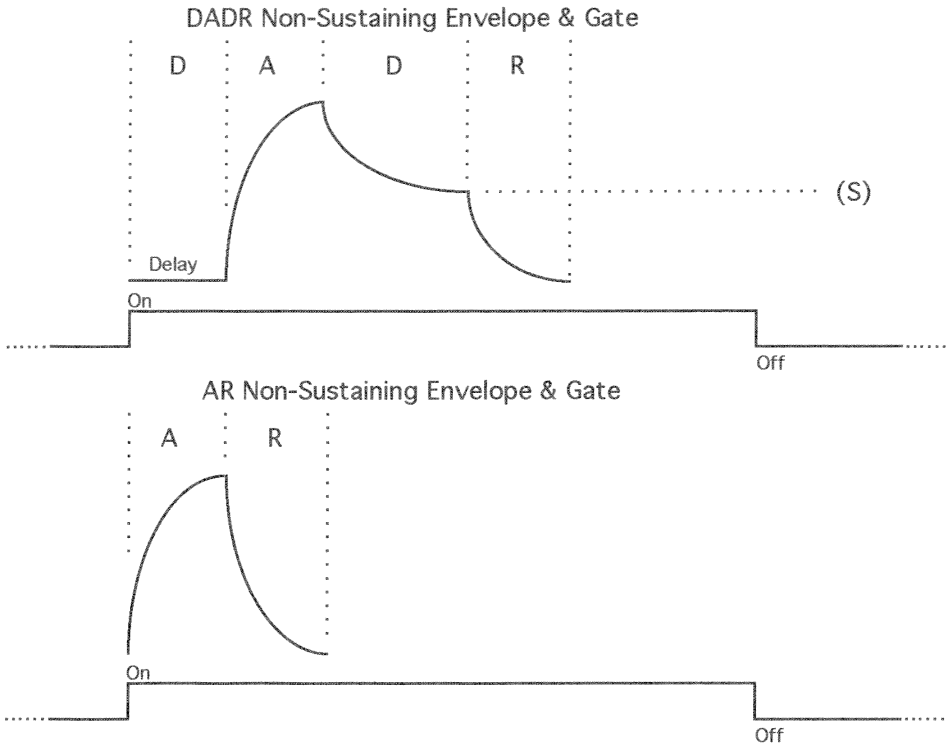


Gallery figures # 2.0–2.3: (2.0) Reference ADSR. (2.1) *Gate Off* earlier in S, so S does *not* last as long. A, D, or R times, *no change!* (2.2) *Gate Off* occurs during D, so D *time* is truncated, or reduced. R starts from *level* of D at instant *Gate Off* occurs, and R falls to zero level. (2.3) *Gate Off* during A segment. A time is truncated due to new location of *Gate Off.* R segment falls to zero level, starting from *level* of A at time *Gate Off* occurs.

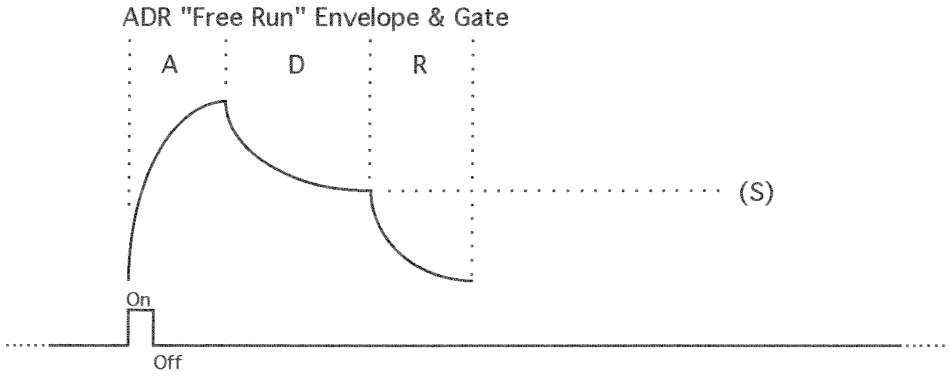
Change of level *does not* cause change of time(s) in any time-based EG such as the classic ADSR. The graphics below show that both maximum and Sustain levels change *proportionally* when the ADSR signal is *attenuated,* or reduced. If max = 10 volts and Sustain = 6 volts, an attenuation of 50% would reduce these levels to 5 volts and 3 volts respectively. Note that attenuation affects all *nonzero* levels (true whether polarity is positive or negative). Zero level cannot be reduced:



DADR and AR Envelope Generators *cannot* "sustain" any level indefinitely during *Gate On,* having *timed* segments only. DADR "(S)" is a *programmable level parameter,* but *S ignores* Gate status. S is not an EG segment as such, but change of *(S)* will change relative *slopes,* or *rates* of Decay and Release segments. (D and R *times* (below) do *not* change as "(S)" level is changed!) The first DADR segment is a programmable *Delay,* which delays EG output. Both DADR and AR behave like the ADSR on *Gate Off* , truncating any timed segment to start the timed *Release segment.*



A "Free Run" or "Latched" Envelope Generator *completes* all timed segments following *Gate On,* ignoring the ensueing *Gate Off.* Although "(S)" may be programmed, it occupies *no time,* acting strictly as a "level hinge" between D and R (as in DADR above). Different designs of the Free Run EG may or may not *restart* on receipt of a new *Gate On* that interrupts the timed cycle.



Designs of time-based Envelope Generators may comprise variations on the principles outlined above. The digital EG typically has *many* timed segments with more-explicit control over levels: the slope, or *rate* of any segment is defined by setting two levels (e.g. L1 and L2) and one time (e.g. T2). An EG may have a timed *Sustain* segment. Monophonic instruments have some unique EG protocols. There are also *rate-based Envelope Generators,* where a change of level causes a change of segment *time.* Discussion of these and other EG issues is provided elsewhere.