**Lesson 13 – Signal Processing Dynamic Based Compressors: Volume Control**

**DYNAMIC PROCESSORS BASICS**

* Dynamic is the range of sound from the quietest to the loudest volume
* The dynamic range of an audio passage is the ratio of the loudest signal to the quietest signal
* Acoustic instrument dynamic range is so great that it would cause problems in recording process
* For signal processors
  + Magnitude of power supply voltage restricts maximum output signal
  + Noise floor determines minimum output signal
* Dynamic processor alters an audio signal based on its frequency content and amplitude level
* The four most common dynamic effects are…
  + Compressors
  + Limiters
  + Gates
  + Expanders
    - After these come other purpose processors…
      * AGC Units
      * Duckers
      * De-Essers
      * Levelers
      * Feedback Suppressors
      * Exciters
      * Enhancers
        + All automatically controlling the volume or dynamics of sounds – just like a volume fader
* All dynamic processors have the common structure
  + A gain control element in the main signal path and a side0chain containing a detector and gain computer
* SIGNAL PATH is the route the main audio takes through the unit
* Signal goes through input circuits on to gain control device and then exits through output circuits
  + Signal chain goes through volume control in the hand on a control analogy
* SIDE-CHAIN is hand that controls the volume
* Side-Chain loop allows patching in filters, EQ or other processors to this path
* Salving or linking dynamics processors causes the units to operate simultaneously when only one unit or chNNEL EXCEEDS THE THRESHOLD SETTING
  + THIS FEATURE PRESERVES STABLE STEREO IMAGINF AND SPECTRAL BALANCE
* All dynamic processors carry out gain control as a function of side-chain level
  + Some use internal signals
  + Some use external or key input
* Only differences between compressor, limiter, de-esser, AGC, ducker or gate are…
  + The type of side-chain detector
  + The gain computer attributes
  + Type of gain control element used
* Introduction of DSP changed the implementation of dynamics processors
* At heart of analog designs are the following with typical specifications as follows…
  + Gain control elements
  + Usually voltage-controlled amplifiers
  + Voltage controlled attenuators

**COMPRESSOR**

* A device where signal gain decreases as input level increases
* This reductions happens at or above a set point AKA threshold

**LIMITER**

* A compressor where most of the output level is not allowed to over a set threshold
* Limiter ratios are usually at or above 10:1
* Often used to reduce occasional peaks

**CLIPPER LIMITER**

* Compressor where no output level is allowed to go over a set threshold
* Clipper limiter ratio is usually between 100:1 and inifinity:1

**COMPRESSION RATIO**

* The amount of dB volume increase that it takes to increase 1dB of signal above the threshold
* Too much compression or limiting could cause a reduction in upper frequencies or cause signal to sound like its pumping

**BASIC COMPRESSORS**

* Reduce dynamic range of signal passing through them
* They turn down loudest signals dynamic
* Starts turning down the signal by the amount set by ration control when input signal exceeds level set by threshold
* GAIN RIDING
  + Before compressors, humans did this at the mixing board
* Set threshold point above which everything will be turned down by certain amount
* Select ratio defining how much the certain amount is

**BROADBAND COMPRESSION**

* Simplest form of compression
* All frequencies are compressed equally and side-chain is equally sensitive to all freq

**COMPRESSOR USES**

* Reduces dynamic range of vocal to enable it to stay present in a mix when competing with other instruments
* Reduce dynamic range of vocalist and instruments that exceed recording capabilities
* Prevent clipping and distortion in live sound systems
* Smooth and balance instruments
* Reduce sibilance
* Produce louder recordings for broadcast
* Even out paging loudness variations
* Control creation of sound
  + Helps determine final timbre by selectively compressing specific frequencies and waveforms
    - EG: fattening drums, increasing guitar sustain, vocal smoothing, bringing a punch to certain instruments

**TWO TYPES OF COMPRESSORS**

* Variable Threshold
  + Most popular type of compressor
  + Allows you to adjust threshold to point where compressor begins to reduce signal gain
* Fixed Threshold
  + Has a fixed point or voltage at which compressor begins to reduce signal gain
  + Must adjust input level of signal to point which threshold is reached
    - Only problem – you must adjust output of compressor to make up level as input is adjusted to reach threshold

**SIDE-CHAIN CONTROLS**

* 4 primary parameters that govern side-chain..
  + Threshold
  + Ratio
  + Attack
  + Release

**THRESHOLD**

* Beginning point of gain adjustment
* Threshold determines when compressor begins to reduce signal gain
* Workable range for compressors is…
  + -40dBu to +20dBu
* A good expander extends range to -60dBu for low-level signals

**RATIO**

* Once signal exceeds threshold setting – the volume will change depending on ratio settings
* Defines proportion of input to output that signal will reduce
* A straight wire has a ratio of 1:1
* A severe ratio is 10:1
* Kinder, gentler ratios are 2:1 and 3:1

**GAIN**

* Sometimes referred to as MAKE-UP GAIN
* Controls desired output level with compression active
* Preferred range for professional apps is \_+12 dB with a center of 0-dB at unity gain

**ATTACK**

* How quickly the function responds to an increase in side-chain input level above the threshold
* ATTACK TIME
  + Time it takes compressor to react to signal once it has risen above threshold
    - For compression and AGC – this defines how quick the gain is turned down
    - For gates and expanders – this defines how quickly the gain is turned up
    - Typically 86%-95%
    - Attack times for compressors normally between 25 ms and 500 ms
    - For expanders with ducking and gates – range changes to 0 ms – 250 ms
    - In expand mode – attack determines rate of gain increase as control signal moves towards set threshold
    - In gate mode – attack time determines how quick the gate opens once control signal exceeds threshold setting
    - In ducker mode – attack determines how quickly the signal is reduced as control signal exceeds threshold setting

**RELEASE**

* How quickly the functions respond to decrease in side-chain input level below threshold
* RELEASE TIME
  + Time it takes compressor to return to normal gain after operating above threshold
    - For compression and AGC – this defines how quickly gain is turned back up once processes have stopped
    - For gates and expanders – this defines how quickly gain is turned down
* Release defined by RC (Resistor-Capacitor) time
  + Resulting in constant dB per second gain change at output
* Important to understand difference between release rate and release time
  + To calculate actual release time
    - Release time = (gain reduction x release setting) / 10 dB
* Typical compressor and expander release setting are between 25 ms and 2 seconds
* In gate mode – these release times determine how quick gate closes at control signal drops below threshold setting
* In expand mode – release time determines how quick signal is turned down as control signal moves below threshold
* In duck mode – release time determines how quick the signal is ramped up when control signal drops below threshold setting

**KNEE**

* This function controls action at point of threshold
* HARD KNEE
  + Does nothing until signal exceeds threshold point and then applies full congestion
* SOFT KNEE
  + Significantly reduces distortion caused by abrupt transition from unity gain to a compressed signal

**AUTOMATIC**

* It adjusts internally depending on signal content

**PEAK**

* Adds a limiter to the compressor to provide a maximum level which no output will flow from unit

**METERS**

* Display gain reductions and input / output levels

**OUTPUT GAIN**

Adjusts compressors output to increase signal level to make up for signal loss related to compression

**SPECIALIZED COMPRESSORS**

* Allows 2 compressors to be linked so stereo imagery can be retained whiles compressor is operating
* Adding parametric EQ in side-chain creates a freq sensitive compressor
* Using a crossover allow split-band compression
* Putting a tracking filter into main signal path and side-chain gives you dynamic EQ
* Comparing broadband and bandpass energies produce relative threshold dynamic EQ
  + Makes terrific de-essers

**FREQUENCY SENSITIVE COMPRESSION**

* A broadband compression with addition of side-chain equalization
* Side-chain EQ takes form of parametric filter, high-cut / low cut filters or all 3
* Multiple parametric filters or graphics are used in side-chain
* If amplitude of freq in side-chain is reduced 0 broadband compressor is less sensitive to it
  + If amp is boosted in side-chain – broadband compression is more sensitive

**SPLIT-BAND COMPRESSION**

* Divides incoming signal into 2 or more frequency bands
* Each band has its own SIDE-CHAIN DETECTOR
  + GAIN REDUCTION applied equally to all frequencies
* After dynamic processing – individual bands are re-combined into one track

**DYNAMIC EQ**

* Dynamically controls boost /cut of parametric filters rather than broadband frequency gain
* Basic dynamic EQ uses a bandpass filter in side-chain with variable centre frequency and bandwidth
* Side-chain detector is sensitive only to passband frequencies
* Parametric filters with matching bandwidth and centre frequency is placed in main signal path
  + Boost /cut od filter is controlled same way a broadband compressor is

**RELATIVE THRESHOLD DYNAMIC EQ**

* Special form of dynamic EQ
* The rms level of bandpass signal in side-chain is compared to rms level of broadband signal
* Difference – level is compared to threshold rather than absolute rms value of bandpass signal
* Advantage – relative amplitude of band of frequencies in comparison to broadband level is maintained of broadband amplitude

**DE-ESSERS**

* Limits or controls the sibilant content of speech
* Limit only high frequency band of audio spectrum
* Looks at average level broadband signal and compares it to average level of bandpass filters in side-chain
* Depends on ratio of sibilant to broadband signals levels
* Performance is consistent and predictable

**PEAK LIMITER**

* Must ensure signal never exceeds set threshold
  + Requires peak responding detectors and a fixed ratio of infinite:1
* Abrupt limiting causes significant alteration of sound
* Primarily used for preventing equipment, media and transmitter overloads
* A peak limiter is to a compressor as a noise gate is to an expander

**PEAK LIMITER USESx**

* Prevent clipping and distortion in power amplifiers
* Protection of loudspeakers from damage resulting from destructive transients
  + Dropped mic
* Prevent overs during recording
* Prevent over modulations of transmitted signal in broadcast

**EXPANDERS & GATES**

* EXPANDER
  + Device where signal gain decreases as its input level decreases and increase signal gain as level increases
* NOISE GATE
  + Device where signals above set threshold are allowed to pass untouched and gain of those signals below threshold ill fully shut off
* EXAMPLES
  + Expander and gates..
    - When applied to drum kit – help to isolate from bleeding and provide a cleaner sound
    - When applied to guitar amp – noise can be greatly reduced
* Common controls on EXPANDER / GATES
  + RANGE
    - Adjusts amount of reduction signal will undergo
    - Amount of reduction could be from slight to completely off
    - This controls how far gate closes
  + THRESHOLD
    - Point where decreasing signal will be turned down
    - Increased signal will be allowed to pass to output
    - It adjusts level at which gate opens and closes
  + RELEASE TIME
    - Time it takes for gain to fall to maximum reduction as selected by range
    - The time it takes the gate to close

**EXPANDERS**

* Compliments compressors by increasing dynamic range of signal passing through it
* Difference between expander and compressor…
  + What gain computer is directed to so with difference between threshold and detected signal level
* Reduces gain for signals below threshold
* Ratio sill defines output change verses input change
* A compressor keeps loud parts from getting louder and an expander makes quiet parts quieter
* Downward expander – most common use is noise reduction

**GATES**

* Gain is reduced below threshold
* Must respond quickly to changes in level
  + Dictation use of peak detector in side-chain
* Uses a fixed ratio of infinity:1
* Typically used to remove background noise between louder sounds
* Provide side-chain EQ and external Key input
* Able to look ahead by delaying main signal a small amount
* Best gate combines looking ahead with pre-amping

**ADDITIONAL SIDE CHAIN CONTROLS**

**HOLD**

* Provided by professional gates
* Typical range of 0-3 seconds
* Determines how long gate remains open after control signal drops below threshold

**DEPTH**

* Provided on all gates
* Typical range of 0 to -80 dB
* Determines how many dB the signal is attenuated when control signal is at or below threshold

**USES & PROBLEMS**

* Gates find use in live sound to reduce crosstalk from adjacent mics, to keep toms from ringing, tighten up sound
* Used to punch up and tighten percussive instruments and drums
* Control unwanted noise
* Once audio drops below threshold output level becomes residual noise of gate
* A gate is the extreme case of downward expansion
* Poorly designed gates cause breathing and clicking
  + Clicking is caused by opening the gate too fast

**PEAK DETECTION, LOOK OUT & PRE-RAMPING**

* PEAK DETECTION
  + Accurately captures and reproduces transient signals
* A look ahead detector works by delaying main audio signal very briefly
* Pre-ramping allows gating on main signal as soon as signal reaches threshold

**Chapter 13 – MRT**

**DYNAMIC RANGE**

* Dynamics of audio found between three level states
  + Saturation
    - Occurs when input signal is so large than an amps supply voltage isn’t large enough to produce required output
  + Average Signal Level
    - Overall signal level of mix resides

METERING

* 2 types of metering are encountered in recording sound
  + - Average (RMS)
      * Determines a meaningful average level of a waveform over time
    - Peak
      * Total amplitude measurements of positive and negative peak signal levels

DYNAMIC RANGE PROCESSORS

* Dynamic range of music is potentially on the order of 120-140 dB

COMPRESSION

* Can be thought of as an automatic fader
* Proportionally reduces dynamic of a signal that rises above the threshold to lesser a volume range
* Most common controls on a compressor
  + Input gain
    - Used to determine how much signal will be sent to the compressor input stage
  + Threshold
    - Setting determines level at which compressors begin to proportionately reduce incoming signal
  + Output gain
    - Determines how much signal will be sent to devices output
  + Slope ratio
    - Determines slope of input-to-output gain ratio
  + Attack
    - Determines how fast or how slow device turns down signal that exceeds threshold
  + Release
    - Determines how slowly or quickly device will restore signal to its original dynamic level one its fallen below threshold
  + Meter
    - Changes compressor meter display to read devices output or gain reductions levels

MULTIBAND COMPRESSION

* Breaks up audible spectrum into various frequency bandwidths through use of multiple bandpass filters

LIMITING

* Used to keep signal peaks from exceeding a certain level in order to prevent overloading of amplifier signals

EXPANSION

* Dynamic range of signal is proportionately increased

THE NOISE GATE

* Another type of expansion
* Allows signal above selected threshold to pass through output at unity gain without dynamic processing