Audio Related Charts, Graphs and Tables of Values

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Basic Audio Related Mathematical Formulae & Definitions

Capacitance
(C)

Capacitance is the ratio of the electric charge given to a body compared to its resultant change of potential. It is usually expressed in Coulombs of charge per Volt of potential change and its basic unit is the Farad. Energy is only stored (but not dissipated) in theoretical (ideal) capacitance. Time constants for audio filters are created with a combination of resistors and capacitors in various configurations. High-pass, Low-pass, Band-pass, and Notch filters can all be created with the appropriate combinations of resistors, capacitors, and amplifiers (usually op-amps). The corner frequency for a simple first order RC filter = 1 / 2 pi* (R x C). The principle of capacitance (and conservation of charge) is involved in the operation of condenser and electret microphones and electrostatic loudspeakers and headphones.

F = (Farad) and μF = micro Farad

μF = 1 X 10 ^ -6 Farads

pF = 1 X 10 ^ -12 Farads

**Note: pi = 3.141592654 (approximately)*

dB (decibel)

1/10 of a Bel. A Bel is the basic unit for the measurement of sound intensity. It is a log scale measurement system used for relating the ratio of two acoustical or electrical parameters. Since electrical Voltage, Current, and Power are used to represent sound through audio signals, the following mathematical relationships may be found to be useful when relating them in terms of outputs and inputs:

dB (Voltage) = 20 log V output / V input
dB (Current) = 20 log I output / I input
dB (Power) = 10 log P output / P input

Note: A doubling of a Voltage or Current represents a 6 dB change. A doubling of Power represents a 3 dB change. For a table detailing the relationship between Voltage, Current and Power ratios in Decibels, turn to our Charts, Graphs and Other Useful Info section of this User's Guide.

dBm

dBm is the power level of a signal expressed in dB, and referenced to 1 milliWatt (0.001 Watt).

Since:

V = (P x Z) ^ ½

Wherein:

V = Voltage in Volts

P = Power in Watts

And

Z = Impedance in Ohms

Therefore:

In a 500 Ohm audio line distribution system,

V_{rms} at 0 dBm = 0.707 Volts

dBu

Pro-level analog signals are often called out in terms of dBu and are at values of +4 dBu which is 1.228 Vrms or 3.47 Volts pk-pk (pure sine wave based).

Gain

Gain is the amplification effect of an electronic system that is often expressed in decibels (dB). For example, an amplifier that has a Voltage gain of 20 dB produces an output Voltage signal that is 10 times greater in amplitude compared to its input. Many special effects audio processors produce "unity" gain. This implies that its output Voltage will be equal to the input Voltage (X 1 gain). Unity gain allows many signal processors to be placed in cascade without concern that the last processor in the chain will become overloaded due to the amplification build-up through each previous processor in the chain.

In general:

Voltage Gain = Av = Vout / Vin

Or -

Voltage Gain in dB = Av (dB) = 20 log Vout / Vin

Total System Gain in dB = Subsystem #1 Gain in dB + Subsystem #2 Gain in dB + Subsystem #N Gain in dB (when the subsystems are connected in a cascaded configuration).

Note: If the subsystem gains are not given in dB, (but given in multiplication factors) the total system gain is the product of the various subsystem gain values. For example, the total Gain = (Subsystem #1 Gain) X (Subsystem #2 Gain) X (Subsystem #N Gain).

The gain (A) of an electrical system can be given in terms of any of the following:

1. Voltage: (Av = Vout / Vin) --- (Voltage Gain in dB = 20 log Vout / Vin)
2. Current: (Ai = Iout / Iin) --- (Current Gain in dB = 20 log Iout / Iin)
3. Power: (Ap = Pout / Pin) --- (Power Gain in dB = 10 log Pout / Pin)

Impedance
(Z)

Impedance is the total opposition, including resistance and reactance, which a circuit element(s) offers to the flow of an alternating current, measured in Ohms.

Z = ((R^2) + (Xc^2) + (Xl^2)) ^ ½

Wherein:

Z = Impedance in Ohms

R = Resistance in Ohms

Xc = Capacitive Reactance in Ohms

Xl = Inductive Reactance in Ohms

Some standard Input and Output Impedance values that you will encounter are as follows:

1. 1 Ohm - The basic unit of measurement for Electrical Resistance, Impedance, or Reactance
2. 2 Ohms (sound re-enforcement systems), 3.2 Ohms (antique audio), 4, 8, 16, and 32, Ohms, (standard Loudspeakers)
3. 8 Ohms – The most common loudspeaker impedance found in the US in 2014.
4. 32 Ohms – Standard earbud impedance.
5. 50 Ohms - Standard Unbalanced Co-Axial impedance for RF signal transmission
6. 75 Ohms - Standard Unbalanced Co-Axial impedance for Television and FM signal transmission
7. 100 Ohms – Output resistance of modern op amp based line level audio equipment
8. 300 Ohms - Standard Balanced impedance for Television and FM signal transmission
9. 377 Ohms - Impedance of Free Space
10. 500 Ohms - Standard Balanced Microphone impedance
11. 600 Ohms - Standard Telephone Exchange Audio line impedance
12. 10,000 Ohms – Input resistance of modern Line Level Op Amp based audio equipment.
13. 2,000 Ohms - Antique Audio (headphones & 1920's vintage horn loudspeakers)
14. 20,000 Ohms - Common single ended input impedance found on vintage Professional Audio Equipment
15. 47,000 Ohms - Common Magnetic Phono Cartridge Loading Impedance
16. 50,000 Ohms - Standard Unbalanced High Impedance Microphone Impedance.
17. 100,000 Ohms - Common Input Impedance on Audio Equipment
18. 1 Meg Ohms - De-Facto Standard, Oscilloscope Input Impedance
19. 10 Meg Ohms - De-Facto Standard, True RMS Voltmeter Input Impedance

Inductance
(L)

The inductance of a circuit component (most often a coil) is the rate of increase in magnetic linkage with an increase of current. The unit of measurement of inductance is the Henry which corresponds to a rate of linkage increase of 10 ^ 8 Maxwell-turns or one Weber-turn per Ampere of current. Energy is stored (but not dissipated) in theoretically ideal inductors. The principle of inductance is a strong element in the operation of electronic transducers such as loudspeakers, magnetic phono cartridges, dynamic microphones, and transformers. Resonant circuits can be created utilizing a combination of capacitors and inductors. The basic resonant frequency of such a circuit is given by Fr = 1 / 2 pi (L x C) ^1/2. This principle can be used to create narrow Band-pass and notch filters. The unit of measurement of inductance = H (Henry)
Note: pi = 3.141592654 (approximately)

Mu (μ)
The small signal amplification factor that a device exhibits in a circuit, often associated with Electron Tubes (and Junction **F**ield **E**ffect **T**ransistors or MOSFETs).

Voltage Amplification = μ x Rl / (Rl + Rp)
Where u (mu) = Device Amplification Factor
Rl = Device Load Resistance in Ohms
Rp = Device Internal Resistance in Ohms

Ohms Law

V = I x R

Wherein:

V = Voltage in Volts,

I = current in Amperes,

R = resistance (in Ohms)

Pi (π)

Pi (Greek Letter) is the symbol that relates the ratio of the circumference to the diameter of a circle.

$\pi = C / D$

Wherein:

C = Circumference of a Circle

D = Diameter of a Circle

$\pi \simeq$

3.14159265358979323846264338327950 29

(Approximately because it is an irrational {non-repeating} number.)

Power

Power (real power) is the time rate for the transfer of usable energy in any system. In other words, Power = Energy / time. In electrical terms, power is given in Watts and has the following relationships to Voltage, Current, and Resistance:

$P = V \times I (\cos \theta)$

Wherein:

P = Power in Watts

V = Voltage in Volts

I = Current in Amperes

θ = the displacement (phase) angle between the Voltage and Current Waveforms (assuming that they are both sine waves)

Also (for purely resistive situations),

$P = (I \wedge 2) R$

And

$P = (E \wedge 2) / R$

Wherein:

R = Resistance in Ohms

Resonance (Electrical)

Resonance occurs in a system in which two elements are operated in quadrature (each element operating at ¼ the signals period) to produce a minimization or maximization of said signal.

$Fr = 1/2\ \pi\ (L \times C)^{1/2}$

Wherein:

Fr = Resonant Frequency in Hertz (Hz)

L = Inductance in Henrys

C = Capacitance in Farads

RMS (root mean square)

The RMS value of a Voltage or Current is the dc equivalent heating value of an alternating current waveform into a resistive load. For a series of sampled V(t) or I(t) data, it is (with V &/or I shown as X in this general expression):

$X_{rms} = ((1/n\ (X1^2 + X2^2 + Xn^2))^{1/2}$

Note: RMS power is a misnomer, as is commonly found associated with audio power amplifier specifications. What is really being presented is the average power calculated into a resistive load using a true RMS Voltmeter per the equation $P_{av} = V_{rms}^2/R$.

Sampling Theorem

In a sampled data system (like the environment in which your DCArt10/DC Forensics10 program is operating), sampling theorem tells us that regularly spaced sampling must occur at least at the Nyquist rate, which is twice the frequency of the highest frequency signal or noise component that is expected to be resolvable by the system (without aliases). In other words, in a system expected to exhibit a frequency response up to 20 kHz, the minimum sample rate will have to be 40 kHz. Because it is impossible to construct an ideal Low-pass filter, the sampling rate will have to be somewhat larger than 2X the desired maximum frequency response value. In practice, a 44.1 kHz sampling rate is generally used in 20 kHz frequency response audio applications (although sometimes 48 kHz and 96 kHz are also used).

Sound Wave Velocity

Sound Wave Velocity in air as a function of temperature is given by the following:

$c = 33{,}100\ (1 + 0.00366t)^{1/2}$

Wherein:

c = Sound Wave Velocity in air in centimeters per second

And

t = temperature in degrees centigrade

Therefore at 70 degrees C, sound will travel at 37,098.6 centimeters per second, or around 830 miles per hour.

Sound Wavelength

The Wavelength of a sound wave is given by the following equation:

$\lambda = c / f$

Wherein:

λ (lambda) = wavelength in centimeters

And

c = Sound Wave Velocity

And

f = frequency in Hz (cycles per second)

Tape Head

A tape head is an electromagnetic device used in a tape recorder to apply and read magnetic signals onto (and from) magnetic tape media. It consists of a coil mounted on a magnetic structure having a "gap" where the tape comes in contact. The tape head gap width in conjunction with the magnetic particle size on the tape media determines the frequency response of the system. This process follows Faradays Law of electromagnetic induction:

Vhead **= - N dø / dt**

Wherein

Vhead = Tape Head Voltage

N = Number of turns of wire on the tape head structure (of a given geometry)

dø / dt = The time derivative of magnetic flux

Since dø / dt is proportional to and increases with frequency, this tape head Voltage signal increases at a rate of 6 dB / Octave and must be compensated for to prevent tape saturation. The process to provide this compensation is called tape equalization.

Thermal Noise (Floor)

Any electrical conductor produces a random noise Voltage as long as it exists at a temperature above 0 degrees K and/or has an electrical resistance greater than zero Ohms. The following formulae can be used to calculate the Root Mean Square value of the thermal noise Voltage of a terminating or source resistance:

$E = (4RkT \times \Delta f)^{1/2}$ or $E = \sqrt{(4RkT \times \Delta f)}$

Wherein:

R = Resistive Component in Ohms (**Ω**)

k = Boltzmann's Constant = 1.38×10^{-23}

Joules / Kelvin (1 Joule = 1 Watt x Second)

T = Absolute or Thermodynamic

Temperature in degrees Kelvin

Δf = Bandwidth of the system in Hertz

(Hz)

E = Root Mean Square (RMS) Noise

Voltage

T (in degrees Kelvin) = Temperature in

Degrees C + 273.15

Time Constant

Time constants are exponential amplitude vs. time functions, which are realized with resistors and capacitors, or resistors and inductors and are often called "Tau"..

Tau = R x C for Resistor/Capacitor circuits

Or

Tau = L / R for Resistor/Inductor circuits

Wherein:

Tau = time constant in seconds

R = resistance in Ohms

C = capacitance in Farads

And

L = inductance in Henries

The relationship between a simple first order filter's corner frequency (Fc) and time constant is as follows:

Fc = 1 / (2 x pi x Tau)

Watt (P)
(Power)

The Watt is a measurement unit of electrical power equal to the ability to do work at the rate of 1 Joule* per second (Joule is a unit of energy).

P = V x I wherein P = power in Watts, V = Voltage in Volts, and I = Current in Amperes.

*1 Joule = 1 Watt x Second

Hot Key Index (for the DCArt Software Product Family)

Here is a list of all known factory-based Hot Keys/Combos and their real world equivalent. These keyboard accelerators (sometimes just referred simply to as “Accelerators”) are listed below:

"1" Play selected area + 0.25 seconds on each side

"2" Play selected area + 0.5 seconds on each side

“3" Play selected area + 1 second on each side

"4" Play selected area + 2 seconds on each side

"A" Select displayed area (same as double click)

CONTROL+"A" Select entire file

CONTROL+"C" Copy selection to clipboard

"D" Select destination

CONTROL+ "E" Select/deselect the pencil (need to be zoomed in far enough to see waveform)

"I" INTERPOLATE Full File (Bi-Modal {BM})

"J" INTERPOLATE LEFT channel only {BM}

“SHIFT + I” INTEROPLATE LEFT channel only {BM}

"K" INTERPOLATE RIGHT channel only {BM}

CONTROL + “I” INTERPOLATE RIGHTchannel only {BM}

“O” INTERPOLATE (Time Domain Mode)

"L" PLAY LOOPED

"M" DROP MARKER

CONTROL+"M" MUTE

"N" GO TO NEXT MARKER

CONTROL+"N" NEW File,

SHIFT+"N" GO TO PREVIOUS MARKER

CONTROL+"O" OPEN File

"P" Open PREFERENCES

Plus Sign (+) Zoom In X2

Minus Sign (-)	Zoom Out X2
CONTROL+"P"	PRINT
“Q”	Activates "Snap Selection to Zero Crossing"
CONTROL+"R"	Brings up Record screen
"S"	SELECT SOURCE
CONTROL+"S"	FILE SAVE
CONTROL+"U"	UNDO LAST EDIT
CONTROL+"V"	PASTE
ALT+BACKSPACE	UNDO
SHIFT+DELETE	CUT
END	REWIND TO Start
F1	Launch HELP file system
SHIFT+F1	CONTEXT SENSITIVE HELP
F6	NEXT PANE
SHIFT+F6	PREV_PANE
HOME	FORWARD TO END
CONTROL+INSERT	EDIT COPY,
SHIFT+INSERT	EDIT PASTE,
LEFT ARROW	NUDGE RIGHT edge of selected area to the left
RIGHT ARROW	NUDGE RIGHT edge of selected area to the right
SHIFT+LEFTARROW	NUDGE LEFT edge of sel. area to the left
SHIFT+RT ARROW	NUDGE LEFT edge of sel. area to the right
RETURN	Default button (this is the cancel button on all filters)
SPACEBAR	Play File or Record/Pause (toggle) when the record dialog box is active.
UP ARROW	Increments the selected parameters
DOWN ARROW	Decrements the selected parameters
CONTROL+"X"	CUT
"X"	ZOOM OUT

"Z" ZOOM IN

CONTROL+"Z" ZOOM OUT FULL

CONTROL+"B" Paste Bleep

ALT+"S" Toggles between Spectrogram& Normal Mode

Esc Exits from the Spectrogram Mode

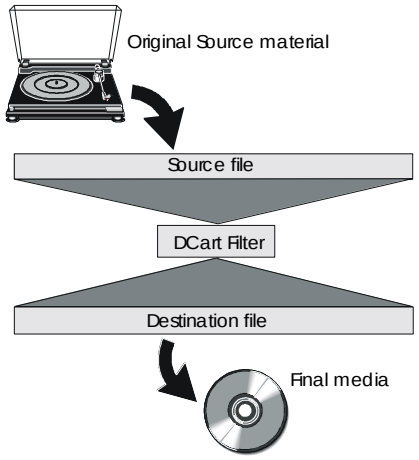
CONTROL+"T" Paste Insert

Mouse Wheel Zoom In & Zoom Out

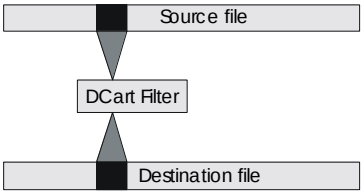
Note: You can customize some of the keyboard accelerators. To do so, go to the View Menu / Toolbars and Docking Windows / Customize / Keyboard

Sync Mode/Non Sync Mode Explanation Process Diagram

The following diagram illustrates the standard filtering process of DCArt10/DC Forensics10 using Classic Edit mode.

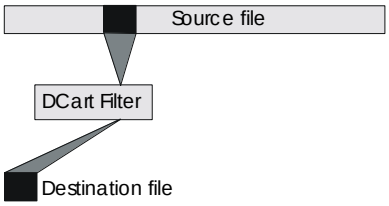


Sync Mode



Sync mode is the default mode of operation for the Classic Editing screen of *DCArt10/DC Forensics10*. In Sync mode, both the Source and Destination files track each other. If you zoom into a section of the Source file, the Destination file will zoom to the same section. When you process the Source file using a *DCArt10/DC Forensics10* filter, the program reads the Source file, processes it, and writes it to the Destination file at exactly the same position as the Source file. This means that if you want to reprocess a section in the middle of a song, just highlight the section in the Source file that needs processing and run the filter again.

Non-Sync Mode



In Non-Sync mode, the highlighted section of the Source file is read and processed by the *DCArt10/DC Forensics10* filter. The processed section is then written to the Destination file, starting at the beginning of the file. If a Destination file already exists, it will be overwritten (a prompt warns you of this). This mode is useful when only a section of the Source file needs to be extracted, or for testing a filter's settings before processing an entire file.

Function & Filter Finder Table

In a program that has as many tools as both DCArt10.xx and DC Forensics10.xx, we thought it might be helpful if you could look up the function to help you more easily find the tool you need.

Functions Unique to DC Forensics10.xx are shown in Italics

Function	**Feature**	**Feature Location**
3 Band EQ	Phono Pre Amp (VPP)	Filter Menu
10 Band Graphic EQ	Graphic EQ	Filter Menu Under "EQ" under "Graphic EQ"
20 Band Graphic EQ	20 Band Graphic EQ	Filter Menu Under "EQ"
30 Band Graphic EQ	*30 Band Graphic EQ*	*Filter Menu Under "EQ"*
32,000 Band Equalizer (FIR Based)	*Spectral Filter*	*Forensics Menu*
33 RPM Record Click Filter	Expert or EZ Impulse Filter	Filter Menu
45 RPM Record Click Filter	Expert or EZ Impulse Filter	Filter Menu
78 RPM Record Click Filter	Expert or EZ Impulse Filter	Filter Menu
80 RPM Record Click Filter (Edison Diamond Disc or Pathé)	Expert or EZ Impulse Filter	Filter Menu
A-Law Compression	A-Law To .wav Conversion	Open/Save File As x.y
About DCart	About DCart	Help Menu
Acoustical Recording Transfer	Phono Pre Amp	Filter Menu
Adaptive Filter	*Adaptive*	*Forensics Menu*
Adaptive Noise Rejection	*Forensics AFDF*	*Continuous Noise Filter*

Add File to End of Existing File	Append To End	Edit Menu/Paste
ADPCM Compression	ADPCM to .wav Conversion	Open/Save File as x.y.
AIFF	Saving a file in the AIFF Format	File\Save As Menu
ALC (Multiband)	Punch & Crunch	Effects Menu
ALC (Wideband)	Dynamics Processor	Effects Menu
Ambience Enhancer	Reverb	Effects Menu
Ambience Reduction	CNF Spectral Subtraction	Continuous Noise Filter under Filter Menu
American 78 RPM Turnover Curve	Phono Pre Amp	Filter Menu
Amplifier Non-linearity Reversal	*Polynomial Filter*	*Forensics Menu*
Amplifier Non-linearity Simulation	Virtual Valve Amplifier	Effects Menu
Amplify Display	Right Slider Control	Next to Right Side of Display
Amplitude Measurement (Relative in dB)	VU Meter	View Menu
Amplitude Measurements and Statistics	*Waveform Statistics*	*Forensics Menu*
Annotate Printed Document	Page Setup	File Menu
Automatic Noise Reduction	EZ Clean Filter	Filter Menu
Automatically Assign Names To Tracks Using CD Internet Database	CD Data base (Internet)	File Menu
Averaging Filter	Averaging Filter	Filter Menu
Average Phase Angle Management	XY Display	View Menu
Background Noise Amplification	*Whisper Enhancer*	*Forensics Menu*
Band Pass (FIR Based)	Brick Wall Filter	Forensics Menu
Balance (audio sound level)	Virtual Phono Preamp	Filter Menu
Balance (gain controls)	File Conversion Filter	Filter Menu
Band Pass (IIR Based)	Band Pass Filter	Filter Menu
Band Pass Filter (Butterworth Response)	Band Pass Filter (Butterworth Checkbox)	Filter Menu
Band Pass Filter (Chebyshev Response)	Band Pass Filter (Chebyshev Checkbox)	Filter Menu

Band Stop Filter (FIR Based)	Brick Wall Filter	Forensics Menu
Bass Control	Phono Pre Amp	Filter Menu
Bass Sound Enhancement	Fat Bass	VVA Under Effects Menu
Batch File Editor	Batch File Editor	Filter Menu
Batch Processing	Batch File Editor	Filter Menu
Binaural DSS – Left Reference	*Continuous Noise Filter*	*Filter Menu*
Binaural DSS – Right Reference	*Continuous Noise Filter*	*Filter Menu*
Both Channels Processed	L/R Icon	Toolbar
Break a File into Smaller Pieces at Markers	Chop File into Pieces	CD-Prep Menu
Brick Wall Filters	Brick Wall Filters	Forensics Menu
Broadcast .wav (BWF)	Create a File having the Broadcast .wav format	File\Save As Menu
Burn a CD ROM	Burn a CD	CD Prep Menu
Buzz Reduction	Harmonic Reject Filter or Impulse Filter	Filter Menu
Cascade Multiple Filters	Multi-Filter	Filter Menu
CD Creation	CD Burner	CD Prep Menu & DC Tune Library
Cell Phone Noise Interference Reduction	*Cell Phone Noise Filter*	*Forensics Menu*
Cepstrum Plots	*Voice ID*	*Forensics Menu*
Change Resolution of File	Change Sample Rate / Resolution	Edit Menu
Change Sampling Rate of File	Change Sample Rate / Resolution	Edit Menu
Channel Mixing / Blending	Channel Blender	Effects Menu
Channel Toolbar Activation	Channel Toolbar	View Menu
Chop File into Pieces at Markers	Chop File into Pieces	CD-Prep Menu
Clone a File	Create a replicate of the opened file	File Menu\Clone Source
Clipping Repair	De-Clipper	Forensics Menu
Columbia LP Curve (Early)	Phono Pre Amp	Filter Menu
Comb Filter 1	Multiple Notch Filters / Multi-Filter	Filter Menu
Comb Filter 2	*Spectral Filter*	*Forensic Menu*

Combine 2 Mono Files into a Stereo File	File Split and Re-Combine	Edit Menu
Comparing File Histogram Statistics	*Comparative Histogram*	*Forensics Menu*
Compress File Size	Save as .mp3 or .wma or .ogg or .oga	File Menu
Compressor (Instantaneous)	*Polynomial Filter*	*Forensics Menu*
Compressor (multiband)	Punch & Crunch	Effects Menu
Compressor (wideband)	Dynamics Processor	Effects Menu
Context Sensitive Help	Point At Feature	Hit F1 Key
Convert a Stereo .wav file to Monophonic	File Conversions	Filter Menu
Convert CDs to MP3s	CD to MP3 Conversion	File Menu
Convert Monophonic .wav file to Stereo	File Converter	Filter Menu
Convert Random to Brown Noise	Multi-Filter (preset)	Filter Menu
Convert Random to Pink Noise	Multi-Filter (preset)	Filter Menu
Convert Random to Seismic Noise	Multi-Filter (preset)	Filter Menu
Convert Redbook Audio on a CD to a .wav file.	Rip CD Feature	File Menu
Convert Stereo .wav file to Stereo Reverse .wav file	File Converter	Filter Menu
Convert .wav file to AIFF Type	Save As	File Menu
Convert .wav file to MP3 Type	Save As	File Menu
Copy a Portion of a .wav file	Copy	Edit Menu
Corner Frequency vs. Time	Filter Sweeper	Effects Menu
Cracked Record Click Remover	Big Click Filter	Filter Menu
Create a Playlist	Open / Create Playlist	File Menu
Create Silence	Mute	Edit Menu
Create Your Own Filter	Multi-Filter	Filter Menu
Cross fade Two .wav files	Paste - Cross fade	Edit Menu
Data Base of Files (DC Tunes)	Open/Create Playlist	File Menu/View Menu
Data Disc Burner	Burn A Data Disc	File or CD Prep Menu

DC Offset Eliminator	High Pass Filter	Filter Menu/Preset
DC Offset Generation	*Polynomial Filter*	*Forensics Menu*
Deep Bass is Missing	Sub-harmonic Synthesizer	Effects Menu
De-Esser	Dynamics Processor	Effects Menu
Delay or Advance timing of One Channel compared to the other	Time Offset feature in File Conversions	Filter Menu
Delete .wav files	Delete Files	File Menu
Differentiator	High Pass Filter (Preset)	Filter Menu
Disguise a Voice	*Voice Garbler*	*Forensics Menu*
Display Colors	Preferences / Display	Edit Menu
Display Setup	Preferences / Display	Edit Menu
Distortion Reduction	*Polynomial Filter*	*Forensics Menu*
Distortion Synthesizer	*Polynomial Filter*	*Forensics Menu*
Dithering	Change Sample Rate / Resolution	Edit Menu
Draw Waveform Segment	Pencil Tool	Toolbar
DSS – Delay Reference	*Continuous Noise Filter*	*Filter Menu*
DTMF Filter	Paragraphic EQ	Filter Menu under “EQ”
Dynamic Enhancer	Dynamic Noise Filter	Filter Menu
Dynamic Noise Filter	Dynamic Noise Filter	Filter Menu
Dynamic Spectral Subtraction (DSS)	*Continuous Noise Filter*	*Filter Menu*
Dynamics Compressor (multiband)	Punch & Crunch	Effects Menu
Dynamics Compressor (wideband)	Dynamics Processor	Effects Menu
Dynamics Expander (multiband)	Punch & Crunch	Effects Menu
Dynamics Expander (wideband)	Dynamics Processor	Effects Menu
Echo 1	Reverb	Effects Menu
Echo 2	Time Offset Feature in File Converter	Filter Menu
Echo Chamber	Echo Effect	Effects Menu
Editing History	Fast-Edit History	View Menu
Enhance Audio Quality	EZ Enhancer	Effects Menu

Enhance Sibilance	Overtone Synthesizer	Effects Menu
European 78 Turnover Curve	Phono Pre Amp	Filter Menu
Evens Harmonic Reject	Harmonic Reject Filter	Filter Menu
Exciter (Harmonic)	Checkbox under the Virtual Valve Amplifier	Effects Menu
Exit the Program	Exit	File Menu or "X" on the Top Right of screen
Expander (Instantaneous)	*Polynomial Filter*	*Forensics Menu*
Expander (multiband)	Punch & Crunch	Effects Menu
Expander (wideband)	Dynamics Processor	Effects Menu
Export Presets	Manage Presets	Edit Menu
Extract Audio From AVI Video	Open Video Files	File Open
EZ Clean Filter	Automatic Impulse, Hiss and Hum Filters	Filter Menu
EZ Enhancer	Complex Audio Enhancement Effects	Effects Menu
EZ Forensics Filter	Adaptive Forensics Audio Filters	Forensics Menu
EZ Impulse Filter	Multiple & Adaptive Impulse Type Filters	Filter Menu
Fade In	Fade-In	Edit Menu
Fade Out	Fade-Out	Edit Menu
Fast Edit Mode	Preferences / General	Edit Menu
File Conversions	File Conversions Filter	Filter Menu
File Information	File Information	View Menu
File Time Reversal	Reverse File	Effects Menu
File Toolbar Activation	File Toolbar	View Menu
Filter Toolbar Activation	Filter Toolbar	View Menu
Find Peak Value	Spectrum Analyzer (Checkbox)	View Menu
Forensics Adaptive Noise Reduction	*Auto Voice Filter*	*Forensics Menu*
Forensics Adaptive Noise Reduction; Frequency Domain	*AFDF Mode in the CNF Filter*	*Continuous Noise Filter – choose AFDF Mode*
Forensics Adaptive Noise Reduction; Time Domain	*Adaptive Filter*	*Forensics Menu*

Formant Identification	*Voice ID*	*Forensic Menu*
Frequency & Amplitude vs. Time	Spectrogram	Forensics Menu
Frequency & Amplitude vs. Time – High Resolution	*High Resolution Spectrogram*	*Forensics Menu*
Frequency Domain Measurements	Spectrum Analyzer	View Menu
Frequency Doubler	*Polynomial Filter*	*Forensics Menu*
Gain Change	Gain Change	Edit Menu
Gain Change vs. Time	Gain Change	Edit Menu
Gain Normalizer	Normalized Gain Scaling	CD-Prep
Gain vs. Time	Gain Change	Edit Menu
Generate Overtones (Evens)	Overtone Synthesizer	Effects Menu
Generate Overtones (Odds and Evens)	Virtual Valve Amplifier	
Generate Sub-harmonics	Sub-harmonic Synthesizer	Effects Menu
Harmonic Reject Filter	Harmonic Reject Filter	Filter Menu
Hear Removed Signal or Noise	Keep Residue Checkbox	In Filter Dialog Boxes where appropriate
High Pass (FIR Based)	Brick Wall Filter	Forensics Menu
High Pass (IIR Based)	High Pass Filter	Filter Menu
High Pass Corner Frequency vs. Time	Filter Sweeper	Effects Menu
High Pass Filter (Butterworth Response)	High Pass Filter (Butterworth Checkbox)	Filter Menu
High Pass Filter (Chebyshev Response)	High Pass Filter (Chebyshev Checkbox)	Filter Menu
High Resolution Frequency Response Contouring	*30-Band Graphic EQ*	*EQ Menu*
Highlight an Area of the .wav file	Left Mouse + Drag	Mouse
Hiss Reduction 1	Continuous Noise Filter	Filter Menu
Hiss Reduction 2	Dynamic Noise Filter	Filter Menu
Hiss Reduction 3	Hiss Filter	Hiss Filter in EZ Clean Filter
Hum Reduction	Notch Filter	Filter Menu
Import Presets	Manage Presets	Edit Menu
Impulse Filter (Easy)	EZ Impulse Filter	Filter Menu
Impulse Filter (Expert)	Expert Impulse Filter	Filter Menu

Insert a Segment into a .wav file	Paste - Insert	Edit Menu
Insert File at Beginning of Another File	Insert at Start	Edit Menu/Paste
Instant Audio Review	Flashback	Multi-Filter
Integrator	Low Pass Filter (Preset)	Filter Menu
Inter-modulation Distortion Reduction	CNF used in Artifact Suppression Mode	Filter Menu
Interpolate a Portion of a .wav file	Paste - Interpolate	Edit Menu
Interpolate Both Channels	"I" Key on Keyboard	Paste Interpolate or Keyboard
Interpolate Left Channel Only	"J" Key on Keyboard	Keyboard
Interpolate Right Channel Only	"K" Key on Keyboard	Keyboard
Last 4 Files Opened	Listing Near the Bottom of the Menu	File Menu
Lateral Cut Record to Monophonic Conversion	File Conversions / Presets	Filter Menu
Lead Vocal Removal	Channel Blender	Effects Menu
Left Channel Process Only	L Icon	Toolbar
Limiter	Dynamics Processor Presets	Effects Menu
Log to Disc	Multi-Filter / Log to Disc Button	Filter Menu
Lossless File Compression	FLAC (.flac)	File Menu (Save As)
Loudness	Volume Control	View Menu
Loudness Maximizer	Punch & Crunch in Compressor Mode	Effects Menu
Low Pass (FIR Based)	Low Pass Filter	Forensics Menu
Low Pass (IIR Based)	Low Pass Filter	Filter Menu
Low Pass Corner Frequency vs. Time	Filter Sweeper	Effects Menu
Low Pass Filter (Butterworth Response)	Low Pass Filter (Butterworth Checkbox)	Filter Menu
Low Pass Filter (Chebyshev Response)	Low Pass Filter (Chebyshev Checkbox)	Filter Menu
Marker (Add)	Right Mouse Click on Display	Right Mouse Button

Marker (Annotate or Label)	Right Mouse Click on Label Marker	Right Mouse Button
Marker (Clear All)	Clear All Markers	Marker Menu
Marker (Clear an Individual Marker)	Right Mouse Click on Delete Marker	Right Mouse Button
Marker (Drop)	Drop a Marker	Marker Menu
Marker (Got Next One)	Got Next Marker	Marker Menu
Marker (Got Previous One)	Got Previous Marker	Marker Menu
Marker (Highlight in between two)	Double Left Mouse click between 2 markers	Left Mouse Button
Marker (Highlight in between two)	Highlight Marked Area	Marker Menu
Marker (Move)	Drag with Mouse	Left Mouse button
Markers (Lock all in Place)	Lock Markers	Markers Menu
Median Filter	Median	Filter Menu
Medium Resolution Frequency Response Contouring	20-Band Graphic EQ	EQ Menu
Mids Control	Phono Pre Amp	Filter Menu
Mix two .wav files together	Paste - Mix	Edit Menu
MME Drivers Setup	Preferences / Soundcard	Edit Menu
Monitor Input vs. Output	Bypass (Checkbox)	All Filter and Effects Dialog Boxes
Mono DSS – Delay Reference	Continuous Noise Filter	Filter Menu
Move .wav file from Destination to the Source Display	Make Destination the Source	File Menu
MP3 Encoder Setup	Preferences / MP3 Encoder	Edit Menu
Mu-Law Compression	Mu-Law To .wav conversion	Open/Save File As x.y
Music from Speech Separator	*DSS in the CNF*	*Filter Menu*
Narrow Crackle Impulse Noise	Narrow Crackle Filter	Filter Menu
Narrowband Noise Rejection	*30 Band EQ*	*EQ Menu*
Noise Gate	Dynamics Processor Presets	Effects Menu
Noise Reduction (Wideband)	Continuous Noise Filter	Filter Menu

Non-linear Transfer Function	*Polynomial Filter*	*Forensics Menu*
Normal Continuous Noise Filter	Continuous Noise Filter	Filter Menu
Normalize Loudness between Multiple .wav files	Auto Leveling Feature	Batch Processor
Notch (IIR Based)	Notch Filter	Filter Menu
Notch Filter vs. Time	Filter Sweeper	Effects Menu
Odds & Evens Harmonic Reject	Multi-Filter	Filter Menu
Odds Harmonic Reject	Harmonic Reject Filter	Filter Menu
Offset Display	Left Slider Control	Next to Right Side of Display
On Line Help	Help, Contents	Help Menu
Open a Playlist	Open / Create Playlist	File Menu
Open a .wav file into Destination Display	Open Destination	File Menu
Open a .wav file into Source Display	Open Source	File Menu
Overtone Synthesis (x 2)	Overtone Synthesizer	Effects Menu
Paragraphic EQ	Paragraphic EQ	Filter Menu under “EQ”
Parametric EQ	Paragraphic EQ	Filter Menu under “EQ”
Paste as a New .wav file	Paste as New File	Edit Menu
Paste Over a Portion of a .wav file	Paste - Over	Edit Menu
Paste Tone	Paste Bleep	Edit Menu/Paste
Pause Play	Play / Record Toolbar	Pause Button on Toolbar
Peaking Filter(s)	Paragraphic EQ	Filter Menu
Pencil Editing	Pencil Icon	Toolbar
Pencil Tool	Pencil Icon	Toolbar
Phase Inversion 1	File Conversions	Filter Menu
Phase Inversion 2	Channel Blender	Effects Menu
Phase vs Time Plot	View Phase vs Time	Forensics Menu
Phono Equalization Curves	Paragraphic EQ Presets	Filter Menu
Pitch Shift	Stretch & Squish Effect	Effects Menu
Place Markers Automatically on Silent spots	Find and Mark Silent Passages	CD-Prep Menu

Play a CD	DC Tune Library	File Menu\DC Tune Library
Play Controls Activation	Play Controls	View Menu
Play File	Play / Record Toolbar	Play Button / Spacebar
Play in a Loop	Loop Play	Loop Play Button on Toolbar
Playlists	DC Tune Library	File Menu/View Menu
Preview Filter or Effect	Preview Button	All Filters and Effects
Print Document	Print	File Menu
Print Preview	Print Preview	File Menu
Printer Setup	Print Setup	File Menu
Process in Batch Mode	Batch File Editor	Filter Menu
Quantize for CD Audio	Quantize for CD Audio	CD-Prep Menu
Ranking Filter	Median Filter	Filter Menu
Real Time Feed through	Multi-Filter / Live Preview Button	Filter Menu
Rebuild the Peak File (Waveform)	Rebuild Peak File	View Menu
Recorder	Record File	Edit Menu or Toolbar
Rectifier	*Polynomial Filter*	*Forensics Menu*
Reduce File Size	Save as .mp3 or .wma or .ogg or .oga	File Menu
Remove Portion of a .wav file	Cut	Edit Menu
Remove Silence from a file Automatically	*Remove Silence Tool*	*Forensics Menu*
Reverberation Simulation	Reverb	Effects Menu
Reverse RIAA EQ Curve	Paragraphic EQ Presets	Filter Menu
Review Real-time Audio	Flashback Mode	Multi-Filter
Rewind to Beginning	Rewind Button	Rewind Button on Toolbar
RIAA EQ Curve	Phono Pre Amp	Filter Menu
Right Channel Process Only	R Icon	Toolbar
Rip a CD	Rip CD Tracks	File Menu
Rumble Reduction 1	Continuous Noise Filter	Filter Menu
Rumble Reduction 2	High Pass Filter	Filter Menu
Run Function	Run Button	All Filters and Effects

Save a Destination Display .wav file	Save Destination As	File Menu
Scalar Amplitude Measurement	VU Meter	View Menu
Scratch & Crackle Filter	EZ Impulse	Filter Menu
Scrub Feature	Variable Speed Playback using the Mouse – Forward and Reverse	Toolbar
Selective Filtering	Sync Files	View Menu
Shelving Filters (Low or High Frequency)	Paragraphic EQ or VPP	Filter Menu
Simulate Tubes and Transistors	VVA	Effects Menu
Sine Wave Synthesis	Make Waves	Edit Menu
Slot Filter (IIR Based)	Notch Filter	Filter Menu
Software Revision Number	About DCart	Help Menu
Sound Activated Recording	Record File / VOX Recording Checkbox	Edit Menu or Toolbar
Sound Card Set Up	Preferences	Edit Menu
Spectral Subtraction Filter	Continuous Noise Filter	Filter Menu
Spectral Inverse Filter	*Normalize a Signal to Constant Power Spectral Density*	*Forensics Menu under Spectral Filter "EQ Mode" Selector*
Spectrogram	*View Spectrogram*	*View Menu*
Spectrogram Options	*Preferences / Spectrogram*	*Edit Menu*
Spectrum Analyzer	Spectrum Analyzer	View Menu
Speech Filter (FIR based)	Brick Wall Filter (presets)	Forensics Menu
Speech Filter (IIR based)	Band Pass Filter (presets)	Filter Menu
Speed Correction	Change Speed Filter	Effects Menu
Splash Screen – On / Off	Preferences / Display	Edit Menu
Split Stereo File into 2 Mono Files	File Split and Re-Combine	Edit Menu
Square Wave Synthesis	Make Waves	Edit Menu
Static Remover	Expert Impulse Filter	Filter Menu
Status Bar Activation	Status Bar	View Menu
Stereo Simulation 1	File Converter (Time Offset)	Filter Menu
Stereo Simulation 2	Reverb	Effects Menu

Stereo Simulation 3	Paragraphic Equalizer, Presets	Filter Menu
Stroboscopes, Printable	Diamond Cut Install Folder	Strobe50Hz.wmf Strobe60Hz.wmf
Sub-Harmonic Synthesis (÷ 2)	Sub-harmonic Synthesizer	Effects Menu
Swept Waveform Synthesis	Make Waves	Edit Menu
Sync Files	Sync Files	View Menu
Synchronize Two .wav files	Sync Files	View Menu
Synthesize Round Bass	VVA	Effects Menu
Synthesize “Sweet” Treble	VVA	Effects Menu
Synthesize “Warm” Treble	VVA	Effects Menu
System Setup	Preferences	Edit Menu
System Status	Status Bar	View Menu (Bottom of Screen)
Tape Equalization Curves	Paragraphic EQ Presets	Filter Menu
THD Measurement	Spectrum Analyzer (Checkbox)	View Menu
Time at Cursor	Time Display	View Menu
Time Compensation Calculator and Corrector	Change Speed	Effects Menu
Time Compression	Stretch & Squish	Effects Menu
Time Delay	Echo Effect	Effects Menu
Time Expansion	Stretch & Squish	Effects Menu
Time Offset	File Conversions	Filter Menu
Time Span	Time Display	View Menu
Time Stamp the Segment	Multi-Filter / Checkbox	Filter Menu
Time Start	Time Display	View Menu
Time Stop	Time Display	View Menu
Timer Recording	Timer Record	Edit Menu
Timing Measurements	View Time Display	View Menu
Tip of the Day Activation	Tip of the Day / Checkbox	Help Menu
Tip of the Day De-Activation	Tip of the Day / Checkbox	Launch, and then after the Splash Screen
Tone Controls	Phono Pre Amp	Filter Menu

Top Octaves Missing	Overtone Synthesizer or Virtual Valve Amplifier	Effects Menu
Total Harmonic Distortion Measurement	Spectrum Analyzer (Checkbox)	View Menu
Track a Frequency	*Frequency Tracking feature used in conjunction with the Spectrogram*	*Forensics Menu*
Track Sub-sonic events	*Subsonic Explorer*	*Forensics Menu*
Treble Control	Phono Pre Amp	Filter Menu
Triangle Wave Synthesis	Make Waves	Edit Menu
Tube Simulator	Virtual Valve Amplifier	Effects Menu
Turnover Curves	Paragraphic EQ Presets	Filter Menu
Undo Edit	Undo	Edit Menu
Universal Impulse Filter	Expert Impulse Filter	Filter Menu
User Discussion Group (BBS / Forum)	User Discussion Group	Help Menu
User Preferences	Preferences	Edit Menu
Valve Simulator	Virtual Valve Amplifier	Effects Menu
Variable Frequency Response vs. Time	Filter Sweeper	Effects Menu
Variable Noise vs. Time	Adaptive Filter	Forensics Menu
Vector Measurement	XY Display (X vs Y)	View Menu
Vertical Cut Record to Monophonic Conversion	File Conversions / Presets	Filter Menu
Vinyl LP Click Filter	Expert Impulse Filter	Filter Menu
Voice Activated Recording	Record File / VOX Recording Checkbox	Edit Menu or Toolbar
Voice Print	*Voice ID*	*Forensics Menu*
Volume Control	Volume Control	View Menu
Volume Control	Virtual Phono Preamp	Filter Menu
Vorbis (Conversion to Ogg Vorbis File format)	Save as .ogg or.oga	File Menu\Save As
VOX Recording	*Record File / VOX Recording Checkbox*	*Edit Menu or Toolbar*
VU Meter	VU Meter	View Menu
VU Meter Scale, Log or Linear	Preferences / General	View Menu
Weighted Median Filter	Median Filter	Filter Menu

White Noise Synthesis	Make Waves	Edit Menu
Wideband Noise Reduction	Continuous Noise Filter	Filter Menu
Whisper Audibility	*Whisper Enhancer*	*Forensics Menu*
Wind Noise	Wind Noise Filter (speech)	Filter Menu
WMA Format File Saving	Save As .wma	File\Save As Menu
WMD Drivers Setup	Preferences / Soundcard	Edit Menu
XY Display	XY Display	View Menu
Zoom (Binary)	Zoom In or Out X2	View Menu or Toolbar
Zoom (Highlighted)	Zoom In or Out	View Menu or Toolbar

Measurement Tools Table

Measurement	Stimulus System	Response System
Acoustical Signature	Calibrated microphone driving sound card input	Spectrogram
Aliasing Products	Swept Sine Wave (Make Waves Generator)	Spectrum Analyzer
Amplifier Linearity	Triangle Wave Generator (Make Waves)	Waveform Display Window
Amplitude Measurements	Time Domain Signal (highlighted by user)	Waveform Statistics in Forensics Menu
Amplitude vs. Frequency	Any signal requiring analysis	Spectrum Analyzer
Amplitude vs. Time	Any signal requiring analysis	Waveform Display Window
Analog Tape Authentication	Look for line frequency or multiple line frequency spectral spikes or look for a higher order noise roll-off rate	Spectrum Analyzer operating in high resolution mode
Analog Tape Recorder Tape Head Azimuth Alignment	Azimuth Reference Tape	XY Display / Vector-scope
Ballistics Fingerprint	Audio Recording of ballistics events to be compared	Spectrogram
Average Phase Angle	Any Binaural Signal	Averaging Selection Box in the XY Display
Cross-talk	Sine Wave into One Channel from the Make Waves Generator; Terminate the	Spectrum Analyzer or VU Meters

	opposite channels input with the proper impedance	
DC Offset	Terminate input with proper input impedance	Waveform Display Window
Dynamic Range	Any combination of signals requiring analysis	VU Meters with Peak Hold
Fall Time	Any signal requiring analysis	Waveform Display Window and Time Display with Markers
Frequency	Any signal requiring analysis	Spectrum Analyzer
Frequency & Amplitude vs. Time	Any signal requiring analysis	Spectrogram
Frequency Distribution	Any signal requiring analysis	Spectrum Analyzer
Frequency Ratio	Any signal requiring analysis	XY Display / Vector-scope
Frequency Response	Swept Sine Wave or Random Noise made by the Make Waves Generator	VU Meter (when using the Swept Sine Wave) or the Spectrum Analyzer (when using the Random Noise Generator)
Hard Disc Recording Time Available	Any signal being recorded	Recording Function
Instantaneous Frequency	Any signal requiring analysis	Waveform Display Window and Time Display with Markers. Calculate: F= 1/t
Inter-modulation Distortion	Dual Sine Wave Tones made with the Make Waves Generator and summed together with “Paste Mix”	Spectrum Analyzer
Left Channel vs. Right Channel	Any signal(s) requiring analysis	XY Display / Vector scope
Linearity	Triangle Wave created using the Make Waves Generator	Waveform Display Window
Noise Floor	Properly Terminated Input	Spectrum Analyzer
Peak Amplitude	Any signal requiring analysis	VU Meter using the Peak Hold feature
Phase Angle	Any pair of signals having coherence	XY Display / Vector-scope
Phase Margin of equipment having a control loop system (1st& 2nd order)	Stereo Square Wave Generator (Make Waves)	Time display window (dampening factor of ‘ring-out’)
Phase vs Time	Two Channels with respect to one another	Forensics Menu – View Phase vs Time
Power Amplifier Frequency Response vs. Output	Swept Sine Wave (Make Waves)	Proper Loading resistor and True RMS reading Voltmeter

Real Time of an Event	Any signal requiring analysis	Timer Recording with Time and Date Stamping
Recording Position	Any signal being recorded	Recording Function
Relative Amplitude (Scalar)	Any combination of signals requiring analysis	VU Meter
Relative Loudness	Any combination of signals requiring analysis	VU Meter
Rise Time	Any signal requiring analysis	Waveform Display Window and Time Display with Markers
Room Acoustical Balance	Random Noise Generator (Make Waves)	Spectrum Analyzer
Room Acoustical Propagation Delay & Reflection	Calibrated microphone driving a sound card input & an Impulse source like a handclap or an impulse created with the “Pencil” feature	Waveform Display Window, Markers and Time Display Feature
Signal to Noise Ratio	Sine Wave @ 0 dB vs. Noise Floor	Spectrum Analyzer
Slew Rate	Square Wave Generator (Make Waves)	Waveform Display Window and Time Display with Markers
Sound Card Performance	Please Refer to Application Note 2 (AN-2)	Please Refer to Application Note 2 (AN-2)
Sound Card Recording Level / Clipping	Audio signal applied to sound Card	Recording Function with recording VU meter and peak indicator
Stereo Separation	Sine Wave into One Channel from the Make Waves Generator; Terminate the opposite channels input with the proper impedance	Spectrum Analyzer, VU Meters or X-Y Display
Tape Recording Speed	Any analog tape recorded signal	Spectrum Analyzer
Time Derivative (dV / dt)	Any signal requiring analysis	Waveform Display Window and Time Display with Markers
Time Interval between Events	Markers	Time Display Feature
Total Harmonic Distortion (% THD)	Any Audio Device requiring performance testing using a Sine Wave stimulus (Make Waves)	Spectrum Analyzer with “Show THD” function and “Show Peak” enabled
Transient Response	Any Active Audio Device with a control loop with a Square Wave applied (Make Waves Generator)	Waveform Display Window

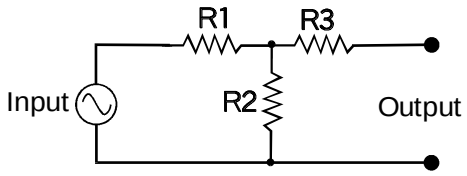
Turntable RPM	Neon or Fluorescent Lamp connected to a known Frequency Source	Printable Strobe discs found in your software.
Voice Print comparison	Audio Signal of Voice(s) to be compared	Spectrogram
Waveform Statistics	Forensics Recordings	Histogram or Histogram vs Time
Whisper Amplifier/Enhancer	Forensics Audio Recordings with very Weak “far” parties	Whisper Enhancer (Forensics Version Only)
Wow and Flutter	Sine Wave (Make Waves)	Spectrum Analyzer

Attenuation Chart

Here is a table of resistance multipliers for a symmetrical (equal input and output impedance) "T" Pad attenuator:

R1 = Attenuator Input Resistor
R2 = Attenuator Shunt Resistor
R3 = Attenuator Output Resistor

(Note: R1 = R3 & the output impedance of the Input Source and the input impedance of the Output Load circuit must also be equal to R1 and R3)



Attenuation (dB)	R1 & R3 (normalized Ohms)	R2 (normalized Ohms)
0.0	0.000000	infinite
0.5	0.028775	17.362
1.0	0.057501	8.6668
2.0	0.114620	4.3048
3.0	0.171000	2.8385
4.0	0.226270	2.0966
5.0	0.280130	1.6448
6.0	0.332280	1.3386
7.0	0.382480	1.1160
8.0	0.430510	0.94617
9.0	0.476220	0.81183
10.0	0.519490	0.70273
20.0	0.818180	0.20202
40.0	0.980198	0.020002
60.0	0.998000	0.0020000
80.0	0.999800	0.00020000
100.0	1.000000	0.000020000

To use this table, multiply the input (or output) impedance of your circuit by the numbers associated with the attenuation that you desire. Remember, this table of values requires that the input terminating impedance and the output terminating impedance of the circuits on each side of the attenuator be present and of the same value. To obtain values of attenuation that are not in this table, merely cascade "T" sections adding up to the value (in dB) which you desire. For example, to achieve 23 dB, cascade a 20 dB section with a 3 dB section.

Decibels

The following table shows the relationship between Voltage, Current, and Power ratios and Decibels:

Numerical Ratio	Voltage or Current Ratio in dB	Power Ratio in dB
1 : 1	0	0
2 : 1	6.0	3.0
3 : 1	9.5	4.8
4 : 1	12.0	6.0
5 : 1	14.0	7.0
6 : 1	15.6	7.8
7 : 1	16.9	8.5
8 : 1	18.1	9.0
9 : 1	19.1	9.5
10 : 1	20	10
100 : 1	40	20
1,000 : 1	60	30
10,000 : 1	80	40
100,000 : 1	100	50
1,000,000 : 1	120	60
10,000,000 : 1	140	70
100,000,000 : 1	160	80
1,000,000,000 : 1	180	90
10,000,000,000 : 1	200	100

Resistor Color Code

Standard RMA (Radio Manufacturers Association) Color Code:

Color	Significant Figure (Mantissa)	Decimal Multiplier (Exponent)
Silver	-	0.01
Gold	-	0.1
Black	0	1.0
Brown	1	10
Red	2	100
Orange	3	1,000 (1K)
Yellow	4	10,000 (10K)
Green	5	100,000 (100K)
Blue	6	1,000,000 (1M)
Violet	7	10,000,000 (10M)
Gray	8	100,000,000 (100M)
White	9	1,000,000,000 (1G)

Note 1: K = Kilo, M = Mega, G = Giga
Note 2: This same color code scheme is sometimes used to identify the values of other electronic components and electrical wires in a system.
Note 3: The tolerance band (next to the Multiplier Band) has the following translation: No Band: +/- 20 %, Silver Band: +/- 10 %, Gold Band: +/- 5%, Red Band: +/- 2%, Brown Band: +/- 1%, Green Band: +/- 0.5 %, Blue Band: +/- 0.25%, Violet Band: +/- 0.10%
Note 4: Some resistors have an additional band denoting the Temperature Co-efficient of the component.

Sound Level

The following is a chart showing some sound sources and their Acoustic Power and Sound Power Levels measured at 10 meters from the source:

Sound Source (measured at 10 meters from source)	**Total Acoustic Power (dB ref. to 10^-12 Watts) (A Weighted)**	**Power Level in dB (A Weighted)**
Very soft Voice	1 NanoWatt	30
Conversational Voice	10 MicroWatts	70
Shouting Voice	1 MilliWatt	90
Auto on Highway	10 MilliWatts	100
Blaring Radio	100 MilliWatts	110
Piano	1 Watt	120
Small Aircraft Engine	3 Watts	125
Pipe Organ	100 Watts	140
75 Piece Orchestra	100 Watts	140
4 Propeller Airplane	1,000 Watts	150
Turbojet Engine	10,000 Watts	160
Ram-Jet Engine	100,000 Watts	170

Dynamic Range

Below is a table of common values of audio system resolution and their associated dynamic ranges:

Number of Bits of Resolution	**Theoretical Maximum Dynamic Range**
4 bits	24 dB
8 bits	48 dB
16 bits	96 dB
20 bits	120 dB
24 bits	144 dB*
32 bits	192 dB*

*Note: These values are not achievable in practice due to the physics associated with the thermal noise floor of electronic amplification systems at room temperatures.

Audio Frequency Spectrum

The following is a listing of some common audio sources and the portion of the audio spectrum that they typically occupy, including their harmonics:

Audio Source	**Fundamentals + Harmonics**	**Fundamental Only**
Accordion	130 Hz to 15 kHz	130 Hz to 1.8 kHz
Bass Drum	50 Hz to 5 kHz	----
Bassoon	65 Hz to 9 kHz	65 to 650 Hz
Bass Tuba	40 Hz to 7 kHz	40 Hz to 375 Hz
Bass Viola	45 Hz to 8 kHz	45 to 300 Hz
Cello	70 Hz to 14 kHz	70 Hz to 900 Hz
Clarinet (Soprano)	150 Hz to 14 kHz	150 Hz to 1.7 kHz
Cymbals (14 inch)	300 Hz to 17 kHz	----
Female Speech*	165 Hz to 10 kHz	165 to 255 Hz
Flute	250 Hz to 14 kHz	250 Hz to 2.5 kHz
Foot Steps	80 Hz to 15 kHz	----
French Horn	70 Hz to 6 kHz	70 to 825 Hz
Hand Clapping	100 Hz to 15 kHz	----
Harmonica	450 Hz to 15 kHz	450 Hz to 1.3 kHz
Jingling Keys	1.5 kHz to 14 kHz	----
Male Speech*	85 Hz to 8 kHz	85 to 180 Hz
Oboe	250 Hz to 15 kHz	250 Hz to 1.7 kHz
Piano	30 Hz to 6 kHz	30 Hz to 4.2 kHz
Piccolo	500 Hz to 15 kHz	500 Hz to 3.8 kHz
Pipe Organ	16 – 32 Hz to 15 kHz	16 – 32 Hz to 8 kHz
Room Noise	30 Hz to 18 kHz	----
Snare Drum	80 Hz to 15 kHz	----
Timpani Drums	50 Hz to 4.5 kHz	----
Trombone	80 Hz to 8 kHz	80 Hz to 500 Hz
Trumpet	180 Hz to 9 kHz	180 Hz to 900 Hz
Violin	190 Hz to 15 kHz	190 Hz to 3 kHz

*Note: Frequency response is specified for mature & healthy adults

Human Hearing Frequency Response vs. Age

(0 dB is referenced to the 20 – 39 year old age group)

(Values are Averages for both Men and Women)

Age	400 Hz	1 kHz	2 kHz	4 kHz	10 kHz
<19	0 dB	0 dB	0 dB	+1 dB	+3 dB
20-29	0 dB	0 dB	0 dB	0 dB	0 dB
30-39	- 1 dB	- 2 dB	- 2 dB	- 3 dB	- 6 dB
40-49	-2 dB	- 3 dB	- 5 dB	-9 dB	-15 dB
50-59	- 4 dB	- 7 dB	- 13 dB	- 20 dB	- 30 dB
60-69	- 5 dB	- 12 dB	- 21 dB	- 32 dB	- 45 dB

Musical Scale

The following table provides the frequencies of four octaves of the tempered musical scale (1/2 step between notes) rounded in integers:

Note	Frequency	Note	Frequency
A	110	A (above middle C)	440
A# (B flat)	117	A# (B flat)	466
B	123	B	494
C (low C)	131	C (high C)	523
C# (D flat)	139	C# (D flat)	554
D	147	D	587
D# (E flat)	156	D# (E flat)	622
E	165	E	659
F	175	F	698
F# (G flat)	185	F# (G flat)	740
G	196	G	784
G# (A flat)	208	G# (A flat)	831
A (below middle C)	220	A (above high C)	880
A# (B flat)	233	A# (B flat)	932
B	247	B	988
C (middle C)	262	C	1,047
C# (D flat)	277	C# (D flat)	1,109
D	294	D	1,175
D# (E flat)	311	D# (E flat)	1,245
E	330	E	1,319

F	349	F	1,397
F# (G flat)	370	F# (G flat)	1,480
G	392	G	1,568
G# (A flat)	415	G# (A flat)	1,661
A (above middle C)	440	A	1,760

Note 1: Standard Pitch is based on the tone "A" of 440 Hz. With this standard, the frequency of Middle C should actually be 261.626 Hz.

Note 2: The entire Musical Scale from C_0 (16.35 Hz) to D9# (9,956.06 Hz) are available as presets in the "Make Waves" Generator (Edit Menu).

Hard Drive Recording Space Consumption

How much hard drive space will you need for your next recording? This handy chart should get you in the ballpark.

Digitization Disc Space Consumption as a function of Recording Mode and Sample Rate @ 16 bit resolution	
Sample Rate & Recording Mode	**Mbytes per Minute**
192 kHz Monophonic	22.500
192 kHz Stereophonic	45.000
96 kHz Monophonic	11.250
96 kHz Stereophonic	22.500
48 kHz Monophonic (Pro-Audio)	5.760
48 kHz Stereophonic (Pro-Audio)	11.520
44.1 kHz Monophonic	5.292

44.1 kHz Stereophonic (Compact Disc)	10.584
22.05 kHz Monophonic	2.646
22.05 kHz Stereophonic	5.292
16.000 kHz Monophonic (Forensics)	1.920
16.000 kHz Stereophonic (Forensics)	3.840
11.025 kHz Monophonic	1.323
11.025 kHz Stereophonic	2.646

Note 1 - Values are given for one process only (such as recording).
Note 2 - Values are given for 16-bit resolution only.
Note 3 - Multiply the above storage rates X 1.5 for 24-bit recording.
Note 4 - Windows currently operates with a 2 Gigabyte limit on .wav file size.

Compact Discs

There are a number of standards for data contained on Compact Discs. They are as follows:

Type	Application	Comments
Red Book	CD Audio / Compact Disc	PCM, 44.1 kHz sampling, 16 bit x 2 channels, 588 bits/frame, 192 bits/frame for the audio stream.
Yellow Book	Computer Data	Data structure based on ISO 9660
White Book	Video CD	MPEG audio/video track encoding
Blue Book	Enhanced Music CD (Audio + Data)	Structure similar to ISO 9660

Orange Book	CD-MO, CD-R & CD-RW	Magneto Optical / CD Write Once / CD Re-Writable
Photo CD Book	Photographs	Based on CD-I Bridge spec.
Multi-session CD	Multiple Session not recordable	Data structure based on ISO 9660

78 RPM Record Turnover Frequency Chart

Type, Brand, or Process	**Turnover Frequency**
Acoustical Recordings	0 Hz
Columbia (1925 - 1937)	200 Hz
Victor (1925 - 1937)	200 Hz
Westrex	200 Hz
Decca (1935 - 1949)	250 Hz
EMI	250 Hz
English Columbia	250 Hz
HMV (1931)	250 Hz
EMI (1931)	250 Hz
London	250 Hz
Blumlein	250 Hz
Columbia (1938 – End)	300 Hz
BSI	350 Hz
Capitol	400 Hz
Mercury	400 Hz
Brunswick	500 Hz
Decca (1925 – 1929)	500 Hz
Edison Laterals (1929)	500 Hz
MGM	500 Hz
Parlophone	500 Hz
Victor (1938 – 1952)	500 Hz
629	629 Hz

Note: Many of these Turnover Curves can be found as presets in the VPP or the Paragraphic EQ.

LP Equalization Chart for Records by Label (Phonographic)

(Prior to the EQ Standardization in ~1955)

Label (Manufacturer)	**Turnover Frequency in Hz**	**Roll-off at 10 kHz in dB**
Angel	500	-13.7
Audio Fidelity	500	-16
Arizona	500	-13.7

Bach Guild	500	-16
Bartok	629	-16
Bethlehem	500	-13.7
Boston	500	-16
Caedmon	629	-16
Capitol	400	-12
Capitol-Cetra	400	-12
Cetra-Soria	500	-16
Classic Editions	500	-13.7
Clef	500	-13.7
Colosseum	400	-12
Columbia	300	-16
Concert Hall	400	-12
Decca	400	-12
Decca FFRR (1951)	300	-14
Decca FFRR (1953)	450	-11
Ducretet-Thompson	450	-11
EMS	375	-12
Epic	500	-16
Esoteric	400	-12
Folkways	500	-16
Haydn Society	500	-16
HMV	500	-16
Kapp	500	-13.7
London	450	-11
London International	450	-11
Lyrichord	500	-16
McIntosh	500	-13.7
Mercury	400	-12
MGM	500	-13.7
Montilla	500	-13.7
New Jazz	500	-13.7
Norgran	500	-13.7
Oceanic	500	-16
Oiseau-Lyre	500	-8.5
Overtone	500	-16
Polymusic	500	-16
Prestige	500	-13.7
RCA Victor (until 1953)	500	-13.7
Remington	500	-16
Riverside	500	-13.7
Romany	500	-13.7
Savoy	500	-13.7
Urania	500	-16
Vanguard	400	-12
Vox	400	-16
Westminster	400	-16

Note: Many of these curves can be found as presets within the Diamond Cut Productions software Virtual Phono Preamp (VPP).

LP Equalization Curves by Curve Name (Phonographic)

The following is a listing of LP turnover frequencies and roll-off attenuation values for the various equalization curves that were used for playback by the phonographic industry (many of which can be found as presets in the Diamond Cut **V**irtual **P**hono **P**reamp {VPP}):

Equalization Curve	**Turnover Frequency**	**Roll-off dB @ 10 kHz**
AES	400 Hz	- 12 dB
Columbia LP	300 Hz	- 16 dB
EMI LP	500 Hz	- 10.5 dB
ffrr (1949)	250 Hz	- 5 dB
ffrr (1951)	300 Hz	- 14 dB
ffrr (1953)	450 Hz	- 11 dB
NAB	500 Hz	- 16 dB
NARTB	500 Hz	- 12 dB
RCA Early Orthophonic	500 Hz	- 11 dB
RCA New Orthophonic	500 Hz	- 13.7 dB
RIAA	500 Hz	-13.7 dB

RIAA Curve Table of Values

Frequency in Hz	Level in dB referenced to 0 dB @ 1 kHz*	Frequency in Hz	Level in dB referenced to 0 dB @ 1 kHz*
20	+ 19.3	800	+ 0.7
30	+ 18.6	1,000	0.0 *
40	+ 17.8	1,500	- 1.4
50	+ 17.0	2,000	- 2.6
60	+ 16.1	3,000	- 4.8
80	+ 14.5	4,000	- 6.6
100	+ 13.1	5,000	- 8.2
150	+ 10.3	6,000	- 9.6
200	+ 8.2	8,000	- 11.9
300	+ 5.5	10,000	- 13.7
400	+ 3.8	15,000	- 17.2
500	+ 2.6	20,000	- 19.6

Note: The RIAA EQ system operates in Constant Amplitude mode below the 500 Hz Turnover Frequency. It also operates in Constant Amplitude mode above the 2120 Hz Rolloff Frequency. The system operates in Constant Velocity mode between the Turnover and the Rolloff Frequencies.

Record Styli Sizes and Types

Record Type	Stylus Size (mil)	Stylus Type
16 inch Transcriptions	2.5	TE
16 inch Transcriptions (very late)	2.0	E
33.3 RPM Monophonic LP	1.0	E
33.3 RPM Stereophonic LP	0.7	E
33.3 RPM Badly worn LP	1.5	TE
33.3 RPM Early Mono LPs	1.5	TE
33.3 RPM CD-4 Quadraphonic LPs	0.2	Shibata
45 RPM Monophonic	1.0	E
45 RPM Stereophonic	0.7	E
1931 to 1935 RCA Pre-Grooved Home Recordings	4.0 – 5.0	S
1930's (late) Lateral 78 RPM Shellac Discs	2.8	TE
Acetate & Aluminum Instantaneous Discs	6.0	TE
Acoustical 78s (very early)	4.0	TE
Acoustical Wide Groove 78 RPM Lateral Discs	3.8	TE
Edison 80 RPM Diamond Discs	3.0 – 3.7	S or C
Edison Blue Amberol Cylinders	3.0 – 4.2	S
Edison Wax Amberol Cylinders	4.2	S
Edison White & Brown Wax, Concert, & Gold Molded Cylinders	7.4	S
Electrical Recordings (Shallow Groove)	2.0	TE
General Purpose 78 RPM	3.0	TE
Metal Stampers*	Depends	BR
Narrow Groove 78s such as Polydor	2.4	TE
Pathe' 78s	3.7	TC
Pathé Etched-label up to 14 inches in diameter	8.0	S
Pathe' Etched-label greater than 14 inches in diameter	16.0	S
Pre-1935 Lateral Cut Electrical 78s	3.3	TE
Standard Groove 78 RPM Discs	3.0	TE
Transcription Recordings	2.3	TE
Transcription. 1930's and 1940's 16 inch Acetates	2.6	TE
Wagner-Nichols Records	0.5	TE

Stylus Type Key: BR = Bi-Radial, C = Conical, TC = Truncated Conical, E = Elliptical, TE = Truncated Elliptical, S = Spherical
* Note: When "stampers" are played on a conventional turntable equipped with a bi-radial stylus, you will need to use the Diamond Cut File Reversal feature so that it can be converted to forward play.

Record Speed Chart (RPM)

Record Type	Speed (RPM)
45s (Victor and others)	45
Berliner 7 inch Records	70
Berliner (pre-1900)	57 to 72
Berliner, Victor, Zonophone (early)	71.3
Early Microgroove (some)	16.66
Edison Black (wax) Amberols (2 min)	160
Edison Blue Amberols (4 min)	160
Edison Brown Wax Cylinders (early)	125 to 144
Edison Brown Wax Cylinders (1892 – 1899)	125
Edison White Wax Cylinder (1888 – 1892)	100
Edison Brown Wax Cylinders (“New Process” – 1900)	144
Edison Concert Cylinders	100
Edison Gold Molded Cylinders	160
Edison Diamond Discs (Vertical Cut)	80
Electrical Era 78s (Europe)	77.92
Electrical Era 78s (US)	78.26
Electrical Era (Edison Lateral “Thin-Cut” – Needle Type)	78.8
Pathe’ (some)	90
Vertical Cut (Pathe´, Brunswick, Okey, Columbia)	80
Victor Acoustical (1908 to 1925)	76.6
Victor Acoustic (early), Berliner	71.3
Victor Acoustical (most)	76.59
Vinyl LPs (Columbia and others)	33.33
Zonophone	71.29

Fractional Speed Record Transfers

You can use the Diamond Cut Change Speed filter to provide Fractional Speed transfer capability from a 45 RPM turntable. Some important Change Speed ratio's are as follows:

1. 45 RPM to 78.26* RPM - Use +73.7 % speed change
2. 45 RPM to 78.8 RPM - Use +75.1 % speed change
3. 45 RPM to 80 RPM - Use +77.1 % speed change
4. Other values can be simply calculated by applying ratio-proportions.

*Note: (Actually it is 78.26086957 which is a 46:1 standard gear reduction from a 60 Hz Line operated Synchronous Motor turning at 3600 RPM.)

Stroboscope Chart (Phonograph)

The following is a chart that you can use to create your own phonograph strobe disc using common line frequencies and RPM values:

RPM	# of Divisions for 50 Hz	# of Divisions for 60 Hz
16	375	450
33.33	180	216
45	133	160
78.26	77	92
80	75	90

Note 1: Actually, two pulses of light are produced per cycle of the line by the power line. But, for improved visibility, it is better to use every other pulse to light up the strobe as is reflected by the chart above.

Note 2: Printable Stroboscope Disc Metafiles can be found you're your Diamond Cut software documentation. The 50 Hz strobe disc is called "**Strobe50Hz.wmf**" and the 60 Hz version is called "**Strobe60Hz.wmf**".

<Users Documents>/DCForensics10/Strobe50Hz.wmf
or

<Users Documents>/DCForensics10/Strobe60Hz.wmf

Note 3: The most effective illumination for a phonograph strobe disc is a power line operated fluorescent or neon lamp.

Tape Speeds in Inches Per Second (ips)

The following is a listing of common speeds used by tape recorders:

Speed (IPS)	Pro Reel to Reel	Home Reel to Reel	Compact Cassette	Micro Cassette
30	**X**	-	-	-
15	**X**	-	-	-
7 1/2	-	**X**	-	-
3 3/4	-	**X**	-	-
1 7/8	-	-	**X**	**X**
15/16	-	-	-	**X**
15/32*	-	-	-	**X**

* This speed is also used by reel-to-reel analog data recorders.

Rotary Head Tape Recorder Speeds

- **DAT:**
  0.321 ips (8.15 mm / sec)
- **VHS:**
  1.31 ips - SP (Standard Play)
  0.66 ips - LP (Long Play)
  0.44 ips - EP (Extended Play)
- **Beta:**
  1.58 ips (4.0 cm / sec) - Beta I
  0.797 ips (2.0 cm / sec) - Beta II
  0.524 ips (1.33 cm / sec) - Beta III

- **U-Matic:**
  3.75 ips

Audio Connection Standards (Connectors)

(Connectors and Cables)

1. Balanced "XLR" (Cannon) Standard
   A. Pin # 1 = Shield
   B. Pin # 2 = Signal + (Signal Hot)
   C. Pin # 3 = Signal - (Signal Cold)

2. 1/4 inch Stereo Phone Plug (TRS) for Balanced Audio Circuits
   A. Tip = Signal + (Signal Hot)
   B. Ring = Signal - (Signal Cold)
   C. Sleeve = Shield

3. 1/4 inch Mono Phone Plug (TR) for Unbalanced Audio Circuits
   A. Tip = Signal + (Hot)
   B. Sleeve = Signal - (Shield & Signal Return Path)

4. RCA / Phono Plug
   A. Tip = Signal + (Hot)
   B. Sleeve = Signal - (Shield & Signal Return Path)

5. RCA Phono Plug Color Codes
   A. Red = Audio, Right Channel
   B. White = Audio, Left Channel
   C. Yellow = Composite Video
   D. Orange = Digital Audio (S/PDIF {Sony/Philips Digital Interface Format})
   E. Green = Y (Component Video - YPbPr)
   F. Blue = Cb or Pb (Component Video - YPbPr)
   G. Red = Cr or Pr (Component Video - YPbPr)

6. Amphenol 3 Pin Balanced Microphone Connector
   A. Pin #1 = Shield
   B. Pin #2 = Signal + (Signal Hot)
   C. Pin #3 = Signal - (Signal Cold)

7. Amphenol 4 Pin Microphone Connector (Balanced and Unbalanced)
    A. Pin #1 = Shield

    B. Pin #2 = + (Hot) Unbalanced (Note: Unbalanced output is with respect to the Shield)
    C. Pin #3 = Signal + (Hot) Balanced
    D. Pin #4 = Signal - (Cold) Balanced
8. DIN5 Pin Connector (Tape Deck I / O Connector)
    A. Pin #1 = Right Channel Record Input
    B. Pin #2 = Shield & Signal Common)
    C. Pin #3 = Right Channel Playback Output
    D. Pin #4 = Left Channel Record Input
    E. Pin #5 = Left Channel Playback Output

9. 1 / 8 inch Mono Phone Plug (TR)
    A. Tip = + (Hot)
    B. Sleeve = - (Shield & Signal Return Path)

10. 1 / 8 inch Stereo Phone Plug {The type used on most Sound Cards}
    A. Tip = Left Channel + (Hot)
    B. Ring = Right Channel - (Hot)
    C. Sleeve = Shield & Signal Common

11. 1 / 8 inch Microphone Input Plug (TRS) {The type used on most Sound Cards}
    A. Tip = Signal + (Hot)
    B. Ring = Phantom Power (~3 to 4 Volts @ ~ 0.75 to 1.5 mA)
    C. Sleeve = Shield & Circuit Common

12. Modular Telephone Jack Wiring (- 48 Volt, 4 terminal, 2 line system / United States)
    A. Red* or Blue or Blue with White Stripe = Line #1 (negative) (Hot)
    B. Green* or White or White with Blue Stripe = Line #1 (positive) (Common)
    C. Yellow* or Orange or Orange with White Stripe = Line #2 - (Hot)
    D. Black* or White or White with Orange Stripe = Line #2 + (Common)
    * Denotes the most standard color code

13. Standard USB (Universal Serial Bus) Pinout and Color Code
    A. Pin #1 = Vbus (5 Volts @ 500 mA) (Red Wire)
    B. Pin #4 = Vbus Ground Return Conductor (Black Wire)
    C. Pin #3 = Data + (Green Wire)
    D. Pin #2 = Data – (White Wire)
    Note: Data + and Data – Conductors are a Twisted Pair

14. 3.5 mm iPhone style Jack Pinout
    A. Pin #1 (Tip) = Left Channel Output
    B. Pin #2 (1st Ring) = Right Channel Output
    C. Pin #3 (2^{nd} Ring) = Ground/Common
    D. Pin #4 (Sleeve) = Microphone Input

15. Stereo Phono Cartridge Wiring Color Standard
    A. Red = Right Channel Signal (Hot)
    B. Green = Right Channel Signal Return
    C. White = Left Channel Signal (Hot)
    D. Black = Left Channel Signal Return

Wire Table

The Wire Table below is useful for calculating losses in power amplifier to speaker system cable connections.

(Standard Annealed Copper)

Wire Gauge in AWG	**Wire Diameter(in Mils)**	**Resistance per Foot in Ohms (@ 20 degrees C)**
0	324.9	0.00009827
1	289.3	0.0001239
2	257.6	0.0001563
3	229.4	0.0001970
4	204.3	0.0002485
5	181.9	0.0003133
6	162.0	0.0003951
7	144.3	0.0004982
8	128.5	0.0006282
9	114.4	0.0007921
10	101.9	0.0009989
11	90.74	0.001260
12	80.81	0.001588
13	71.96	0.002003
14	64.08	0.002525
15	57.07	0.003184
16	50.82	0.004016
17	45.26	0.005064
18	40.30	0.006385
19	35.89	0.008051
20	31.96	0.01015
21	28.46	0.01280
22	25.35	0.016140
23	22.57	0.02036
24	20.10	0.02567

Wire Gauge Rule of Thumb:

Conductor resistivity roughly doubles for every 3 AWG increase. (Resistivity = 1 / Conductivity)

Note 1: The temperature coefficient of resistance for copper wire $\simeq$ + 0.41% / degree C (4,100 ppm / degree C) referenced to 20 degrees C.

Note 2: The resistance of a 2 conductor cable will be need to be doubled to account for the round trip.

Note 3: Generally, audio power signals are carried with 16 AWG or lower conductors except in some low power 25 or 70 Volt Constant Voltage audio distribution systems (from power amplifiers under 100 Watts).

Note 4: Except in some very unusual circumstances, no wire sizes higher than 16 AWG should be used to carry the output of an audio power amplifier to an audio system's loudspeakers, especially in permanent building installations.

Note 5: C10100 Oxygen-Free Electronic (OFE) copper wire is 99.99% pure copper (Cu) with $\leq$ 0.0005% O_2. It exhibits 1% lower resistance per foot compared to standard Cu wire (which is of little benefit in audio applications).

Telephone Touch Tone Frequency Chart

The Spectrum Analyzer can be used to detect and identify a telephone number dialed when used in conjunction with this chart. Also included are the letters A, B, C, and D, which was used in the US military's Autovon phone system.

1	**2**	**3**	***A***	**697** (687–708)
4	**5**	**6**	***B***	**770** (759–782)
7	**8**	**9**	***C***	**852** (839–865)
*****	**0**	**#**	***D***	**941** (927–955)
1209 (1191–1227)	**1336** (1316-1356)	**1477** (1455-1499)	**1633** (1609-1658)	**Frequency (Hz)**

Note 1: The tolerance for these frequencies is +/- 1.5 %, and the range of which is shown in parenthesis. The highest frequency must also be as loud as the lowest frequency, or as much as 4 dB louder (this difference in level is referred to as "twist."

Note 2: Call waiting tone in the US is 440 Hz.

Note 3: Caller ID on call waiting in the US is 2130 + 2750 Hz.

Worldwide Dial Tone Frequencies

(Telephone Signals)

Country	Freq.1	Freq. 2	Country	Freq.1	Freq.2
Belgium	425 Hz	Not Used	Singapore	270 Hz	320 Hz
France	440 Hz	Not Used	South Korea	350 Hz	440 Hz
Germany	425 Hz	Not Used	Sweden	425 Hz	Not Used
Israel	400 Hz	Not Used	Switzerland	425 Hz	Not Used
Italy	425 Hz	Not Used	Taiwan	350 Hz	440 Hz
Japan	400 Hz	Not Used	U.S.	350 Hz	440 Hz
Netherlands	425 Hz	Not Used	U.K.	350 Hz	440 Hz
Norway	425 Hz	Not Used	Venezuela	425 Hz	Not Used

*Note1: These can be useful as a reference frequency when measuring DTMF signals

Note 2: Further information can be found in an ITU document located at:
http://www.itu.int/ITU-T/inr/forms/files/tones-0203.pdf

Common Audio Electron Tubes / Valves

Note: Some of these tube transfer functions are implemented in the Diamond Cut Virtual Valve Amplifier (VVA).

Audio Power Amplification Output Tubes

Tube Type	Tube Configuration	Output Power (Class AB1, 2 tubes used in a Push-Pull topology – typical levels)	Comments
2A3	Power Triode	8 Watts	Directly Heated Cathode (Vintage Tube)
6BQ5 / EL-84	Power Pentode	15 Watts	9 pin miniature base
6CA7 / EL-34	Power Pentode	35 Watts	English Design
6K6	Power Pentode	8 Watts	Early Octal Base Power Pentode
6L6GC / 5881	Beam Power Pentode	25 Watts	Very Common Tube
6V6	Beam Power Pentode	12 Watts	Low Power Hi-Fi
6550	Beam Power Pentode	75 Watts	Hi-Pwr Hi-Fi
7027	Beam Power Pentode	30 Watts	Often used in P-P Parallel Configuration
8417	Beam Power Pentode	75 Watts	Often used in P-P Parallel in high-power PA applications
EL-37	Power Pentode	25 Watts	Early 50s English Hi-Fi Pwr Amplifiers
KT-66	Beam Power Tetrode	30 Watts	English Design Hi-Fi Power Amplifiers
KT-88	Beam Power Tetrode	70 Watts	English Design Hi-Fi Power Amplifiers

Audio Amplification Signal Tubes

Tube Type	Tube Configuration	Key Characteristic	Comments
6C4	Single Medium Mu Triode	Cathode Follower	Buffer / Low gain Preamp
6CG7 / 6FQ7	Dual Medium Mu Triode	Phase Inverter / Driver	Used in Power Amplifiers
6EJ7 / EF164	Single Hi Gain Pentode	Wide Bandwidth	Used in Tuners & Low Level Audio Stages
6SL7	Dual Hi Mu Triode	Low Noise / Low Level	Used in Preamplifiers & Mixers
6SN7	Dual Medium Mu Triode	Phase Inverter / Driver	Used in Power Amplifiers
12AT7	Dual Hi Mu Triode	RF Mixer / Hi Levels of Harmonic Distortion	Used to produce “tube warmth” via high level of Harmonic Distortion
12AU7	Dual Medium Mu Triode	Phase Inverter / Driver	Used in Power Amplifiers
12AX7	Dual Hi Mu Triode	Low Noise / Low Level	Used in Preamplifiers & Mixers
6267 / EF86	Single Hi Gain Pentode	High Gain / Low Noise	Used in Microphone Preamps

Audio Rectifier Tubes

Tube Type	Tube Configuration	DC Current Capability	Comments
5AR4	Octal base, Indirectly Heated Cathode	270 mA	Hi Power Output Amplifiers
5U4	Octal base, Directly heated Cathode	200 mA	Medium Power Output Amplifiers
5Y3	Octal base, Directly Heated Cathode	140 mA	Low Power Amplifiers
6V4 / EZ-80	9 Pin Miniature Indirectly Heated Cathode	90 mA	Preamps / Tuners / Mixers
6X4	7 Pin Miniature Indirectly Heated Cathode	70 mA	Preamps / Tuners / Mixers
6X5	Octal Indirectly Heated Cathode	80 mA	Preamplifiers / Tuners / Mixers
80	4 Pin, Directly Heated Cathode	140 mA	Vintage Medium Power Amplifiers