Soundcards for Amateur Radio

RVARC Club Meeting – October 1, 2009
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Outline
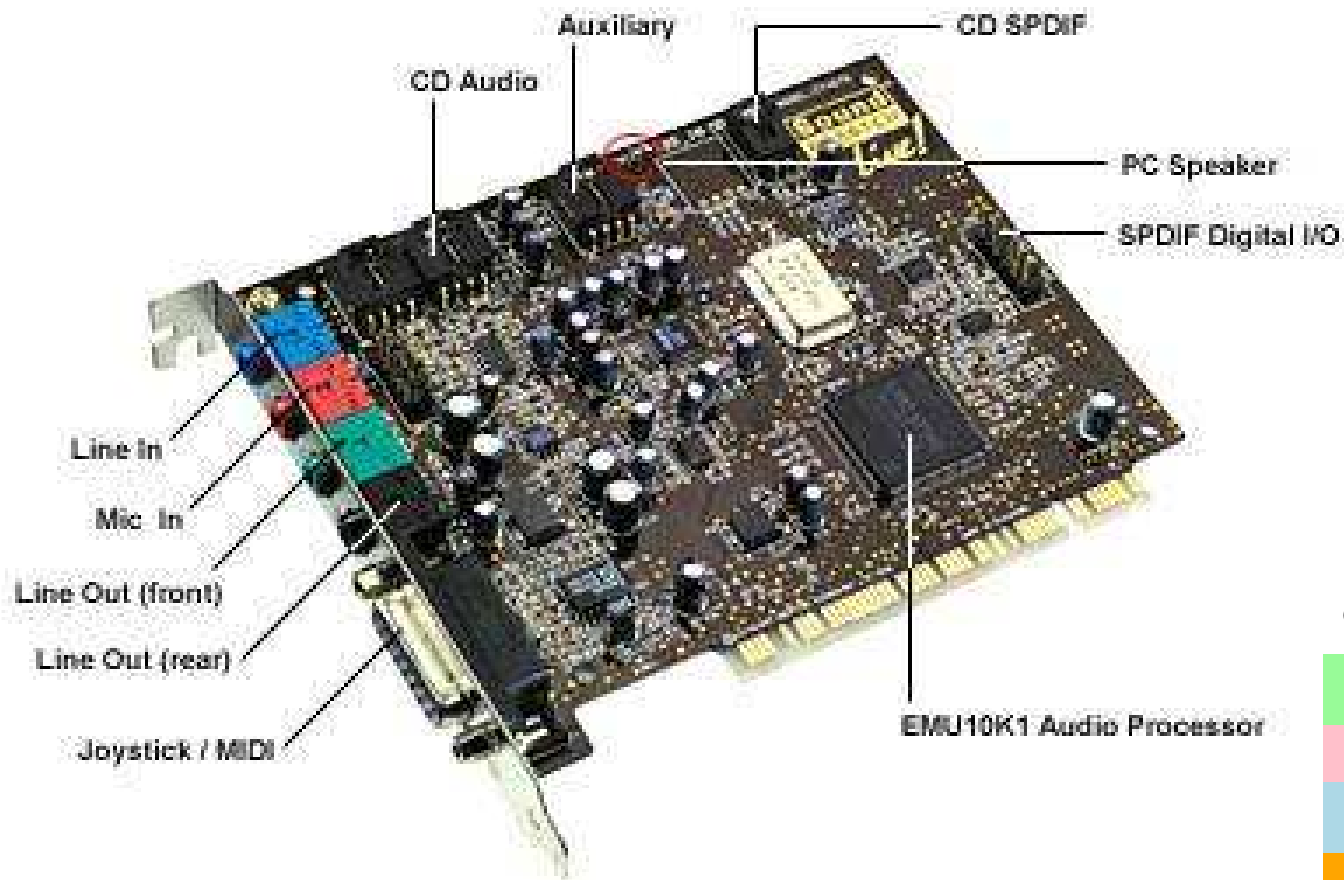
- ## Background
  - Block diagram, drivers, other software
- ## Applications
  - Some common applications
- ## Performance
  - Specification, types of cards
  - Critical issues

Soundcard Applications

- Soundcards typically used by Amateurs for:
  - Audio Recording and Playback
    - Contesting – Microphone in and Line In/Out
    - Music, Video Entertainment, etc.
    - Windows System Sounds
  - Test Equipment (scope, spectrum analyzer)
  - Digital Modes – RTTY, PSK31, DRM, others
    - Usually using Mono mode
    - Normally soundcard performance not a problem.
  - Software Defined Radio (SDR)
    - Used as In Phase & Quadrature Phase (I/Q) analog to digital and digital to analog conversion.
    - Requires Stereo connections.
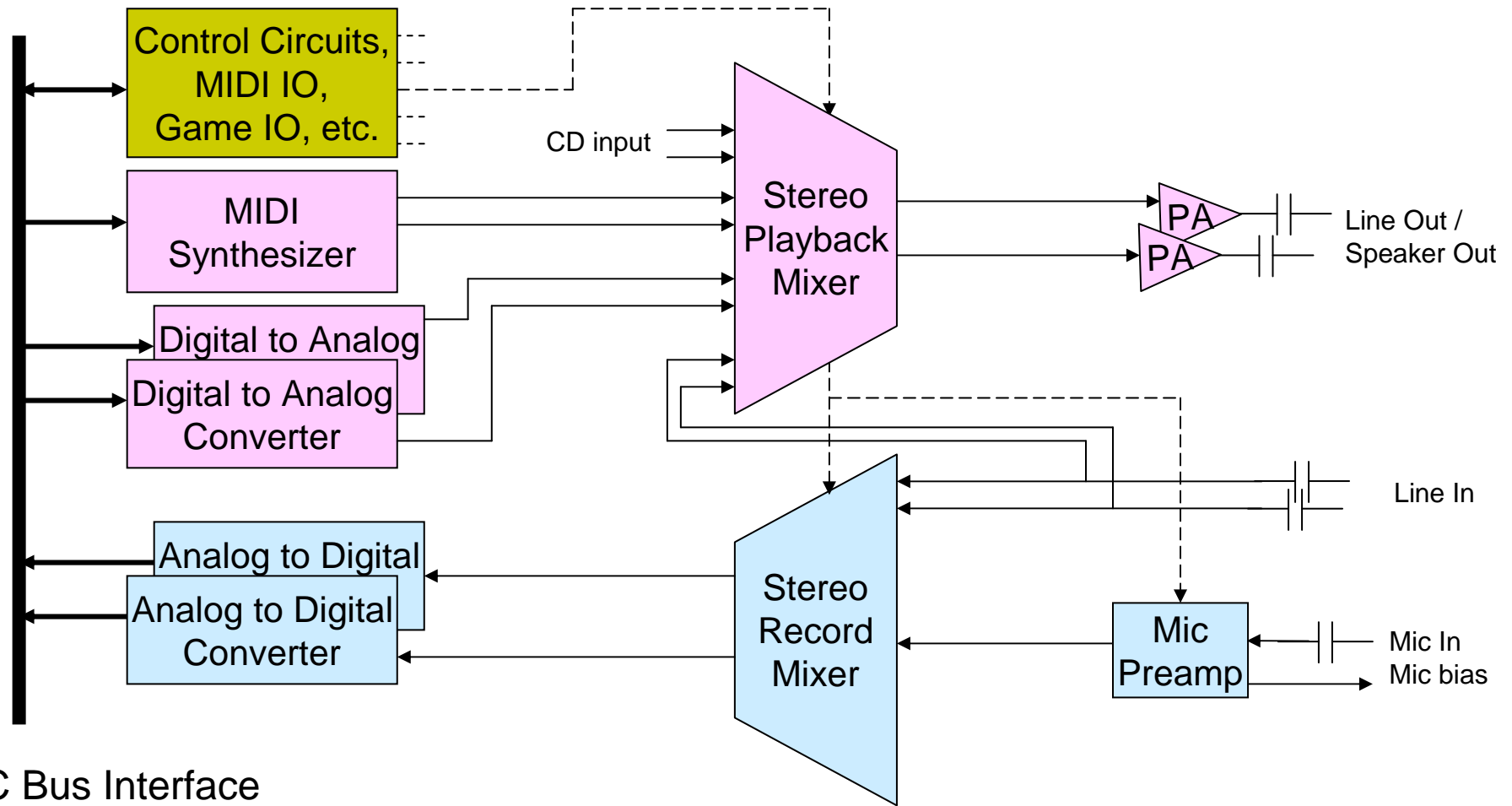   - Soundcard performance is usually extremely important.

SB Live! (16 bit stereo card)

CD Audio
Auxiliary
CD SPDIF
PC Speaker
SPDIF Digital I/O
Line In
Mic In
Line Out (front)
Line Out (rear)
Joystick / MIDI
EMU10K1 Audio Processor

Sound card color code:

Color	Connector
Lime Green	Line-Out, Front Speakers, Headphones
Pink	Microphone In + DC element bias
Light Blue	Stereo Line In
Orange	Center Out and Subwoofer
Black	Analog line-level Rear Surround Speakers for 5.1 and 7.1 systems
Gray	Middle Surround Speakers for 7.1 systems
Gold	Game Port / Midi

Typical Block Diagram

Control Circuits, MIDI IO, Game IO, etc.

MIDI Synthesizer

Digital to Analog

Digital to Analog Converter

Analog to Digital

Analog to Digital Converter

CD input

Stereo Playback Mixer

PA

PA

Line Out / Speaker Out

Stereo Record Mixer

Line In

Mic Preamp

Mic In

Mic bias

PC Bus Interface

Many soundcards have additional mixer inputs and outputs

Software and Drivers

- Windows XP – standard WDM software driver is KMixer.SYS (Kernel Audio Mixer)[1].
  - Mixes multiple PCM audio streams.
  - Performs format, bit-depth and sample-rate conversion.
  - Provides speaker configuration and channel mapping.
  - Unfortunately has 30 milliseconds minimum latency.
- Audio Stream Input Output (ASIO) – available for many soundcards (but not all). Developed by Steinberg Media Technologies GmbH
  - Its for Windows systems – bypasses KMixer.SYS
  - Provides minimum latency
  - Bits In = Bits out (avoids format conversion)
- Soundvol32.exe – You've seen this interface for enabling and disabling inputs and outputs, setting volume and balance levels, enabling the microphone pre-amp, etc.
  - Hint: put a link to it the Quick Launch Toolbar.
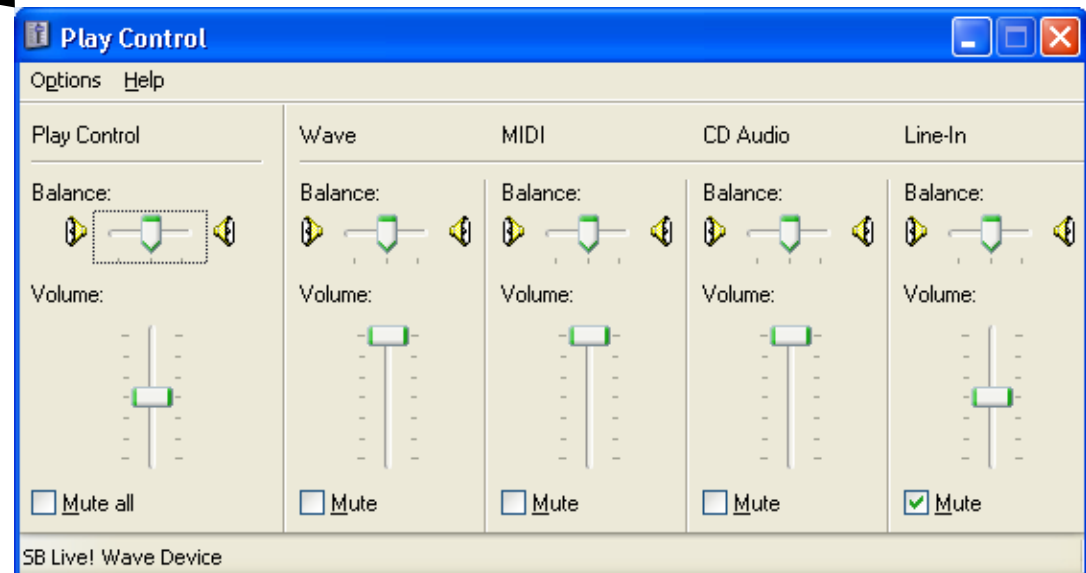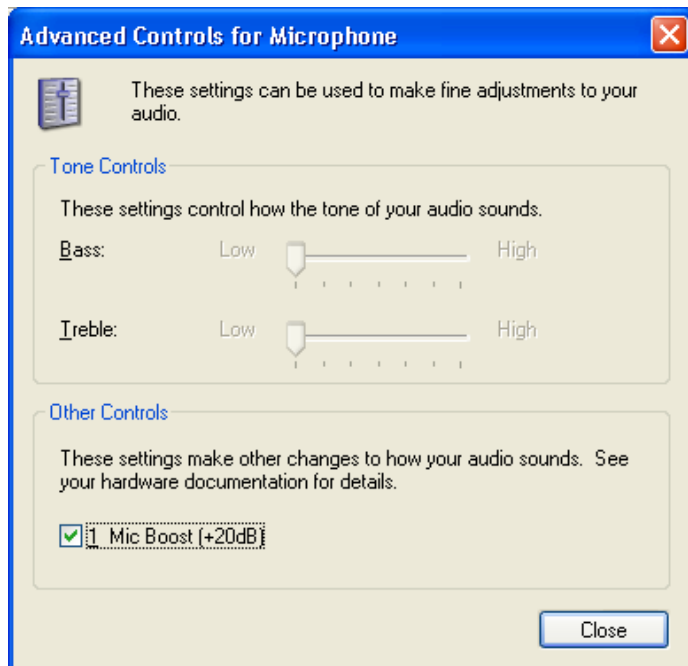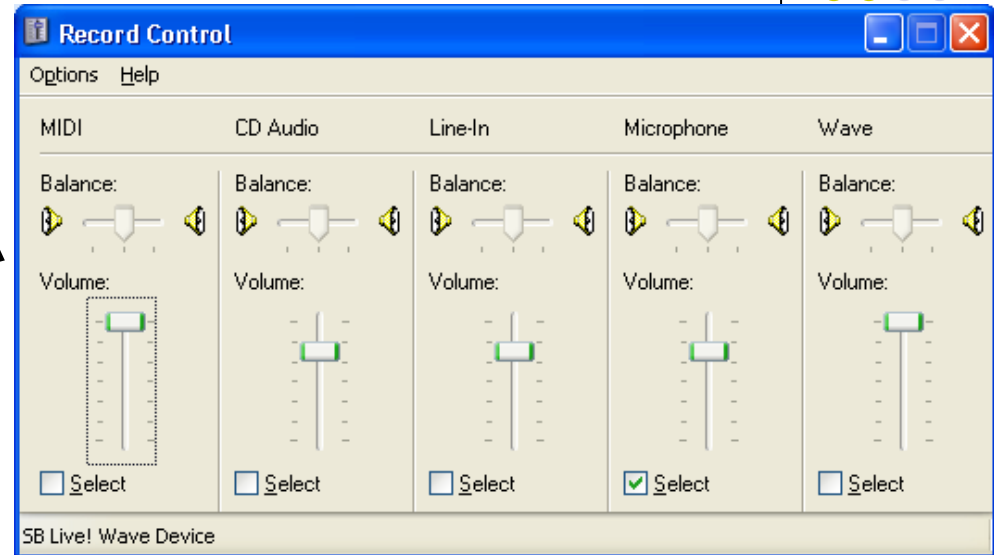
[1] From Wikipedia

Soundvol32.exe

Record Mixer control

Playback Mixer control

Mic Preamp control

Record Control

Options   Help

MIDI	CD Audio	Line-In	Microphone	Wave
Balance:	Balance:	Balance:	Balance:	Balance:
Volume:	Volume:	Volume:	Volume:	Volume:
☐ Select	☐ Select	☐ Select	☑ Select	☐ Select

SB Live! Wave Device

Advanced Controls for Microphone

These settings can be used to make fine adjustments to your audio.

Tone Controls

These settings control how the tone of your audio sounds.

Bass: Low ———————— High

Treble: Low ———————— High

Other Controls

These settings make other changes to how your audio sounds. See your hardware documentation for details.

☑ 1 Mic Boost (+20dB)

Close

Play Control

Options   Help

| Play Control	Wave	MIDI	CD Audio	Line-In
Balance:	Balance:	Balance:	Balance:	Balance:
Volume:	Volume:	Volume:	Volume:	Volume:
☐ Mute all	☐ Mute	☐ Mute	☐ Mute	☑ Mute

SB Live! Wave Device

Audio Recording

- Audio Recorders bundled with Windows are sometimes very limited.
- Free excellent program is Audacity, available from Sourceforge.net.
  - Permits recording
  - Allows editing audio waveforms.
- Many ham logging program allow both recording and playback of audio for contests, general operating, etc.
  - Playback can hold canned contest voice messages
  - Writelog can record a contest.
- Some loggers allow control of soundcard in real-time
  - When switching from transmit to receive for example.

Audacity 1.3.9
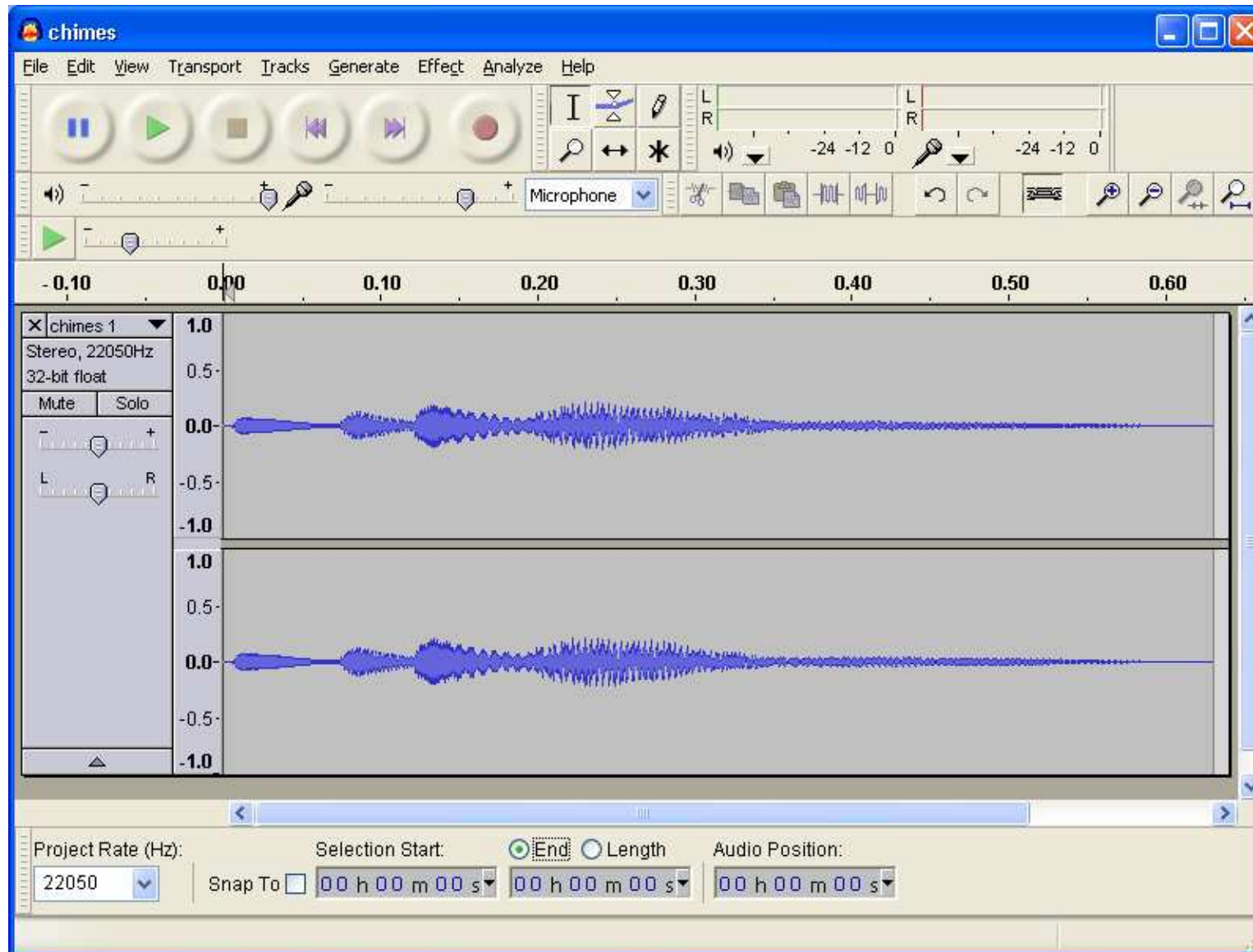
Windows Sound Events

- Windows emits sounds for certain events (Startup, Shutdown, Various warnings, Web page clicks).
  - These are mixed with anything else being generated.
  - Many times heard on-the-air when they should not be.
  - Windows XP provides multiple sound schemes (profiles).
    - 'No Sounds' allows turning off all system sounds. Highly recommend to select this profile before using soundcard with a radio.
    - Control Panel → Sounds and Audio Devices → Sounds Tab → No Sounds.
    - You can change it back to default (or a previously saved profile) at any time.

Sounds and Audio Devices Properties

Volume | Sounds | Audio | Voice | Hardware

A sound scheme is a set of sounds applied to events in Windows and programs. You can select an existing scheme or save one you have modified.

Sound scheme:

No Sounds

Save As...   Delete

To change sounds, click a program event in the following list and then select a sound to apply. You can save the changes as a new sound scheme.

Program events:

Windows
  Asterisk
  Close program
  Critical Battery Alarm
  Critical Stop
  Default Beep

Sounds:

Browse...

OK   Cancel   Apply

HF Digital Modes

- Soundcard is used as D-A and A-D converter, usually only mono needed.
- Signals usually have bandwidth of less than 3 KHz (normal SSB rig)
- PC acts as a DSP-based audio modem – modulating and demodulating signals from the digitized audio samples.
  - RTTY, PSK31, and SSTV are the most common.
  - Many other modes exist.
- Lots of links to free software.
  - MMTTY, Digipan, MMSSTV, EasyPAL are some favorites.
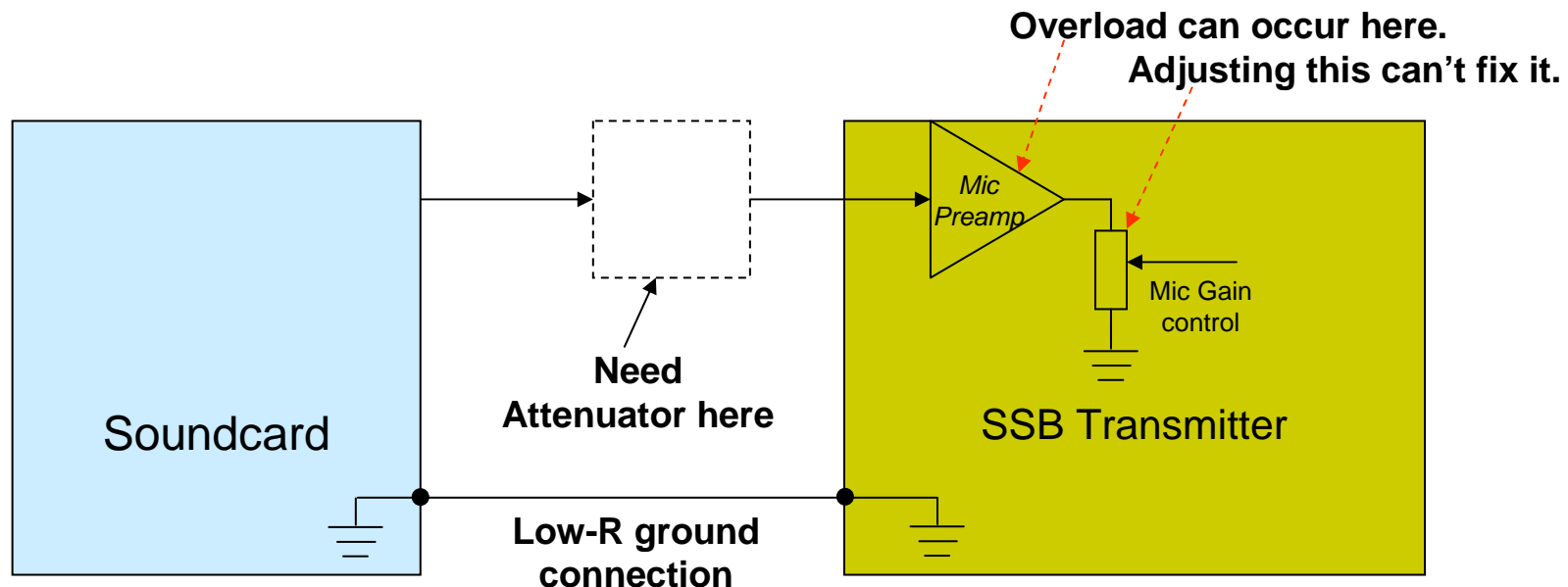- CW decoder: CWGet is popular program.

Performance for baseband digital modes

- SSB receiver performs image and opposite rejection – soundcard receives MONO audio stream for digitization.
  - Soundcard performance does not impact these.
- Typical 16-bit soundcards have 12-to-15 ENOB (Effective Number Of Bits) [70-88 dB dynamic range].
  - Could impact adjacent-channel audio rejection against very strong signals within the receiver's passband.
    - Narrow IF filters reduce this problem a lot.
- Soundcard output is likely more linear than SSB final amplifier.
  - SSB PA linearity improves when peak power is reduced. But PA distortion still likely dominant over soundcard.
  - Must prevent soundcard clipping on signal peaks.
  - Peak-to-Average-Power ratio for some digital modes exceeds 10 dB.
    - Must exercise care when controlling average power output.

Caution when using soundcard for Transmitting

- Amateur HF rigs require about 10 millivolts at the microphone jack input. When the Speech processor is on, it can pick up 1 millivolt level signals.

- Soundcard output is on the order of 1 to 2 volts peak-peak.

- 10000% to 100000% overdrive condition (40 dB to 60 dB).

Overload can occur here.
Adjusting this can't fix it.

Soundcard

Need Attenuator here

Mic Preamp

Mic Gain control

SSB Transmitter

Low-R ground connection

Common HF Frequencies for digital modes

Band	Common Frequencies
160 meters	RTTY: 1.810 occasionally
80 meters	PSK: 3.580 RTTY: 3.610-3.630 less common now
40 meters	RTTY: 7.040 for DX, 7.080 rare now PSK: 7.060-7.080
30 meters	10.130-10.145
20 meters	14.060-14.095. Busiest band for digital
17 meters	18.100-18.110
15 meters	21060-21080
12 meters	24.920-24.930
10 meters	RTTY 28.080 Other 28.110-28.125

Test Equipment
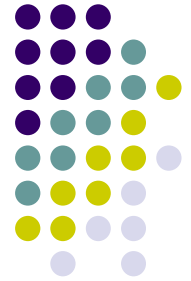
- Audio Test Equipment software available
  - Oscilloscope
    - Displays time samples of data like a dual-channel oscilloscope.
  - Spectrum analyzer
    - Uses FFT of time data to display spectrum.
  - Audio Performance: RightMark (hard to find now)
    - Characterizes dynamic range, distortion of audio card.

Spectran V2

- Spectrum analysis from soundcard input.
- Popular for weak-signal discovery & capture.
  - Can see signals 'buried' in noise. 241 GHz QSO showing (W) 2SZ & Rx drift.
- Sub one-hertz filter bandwidth possible.
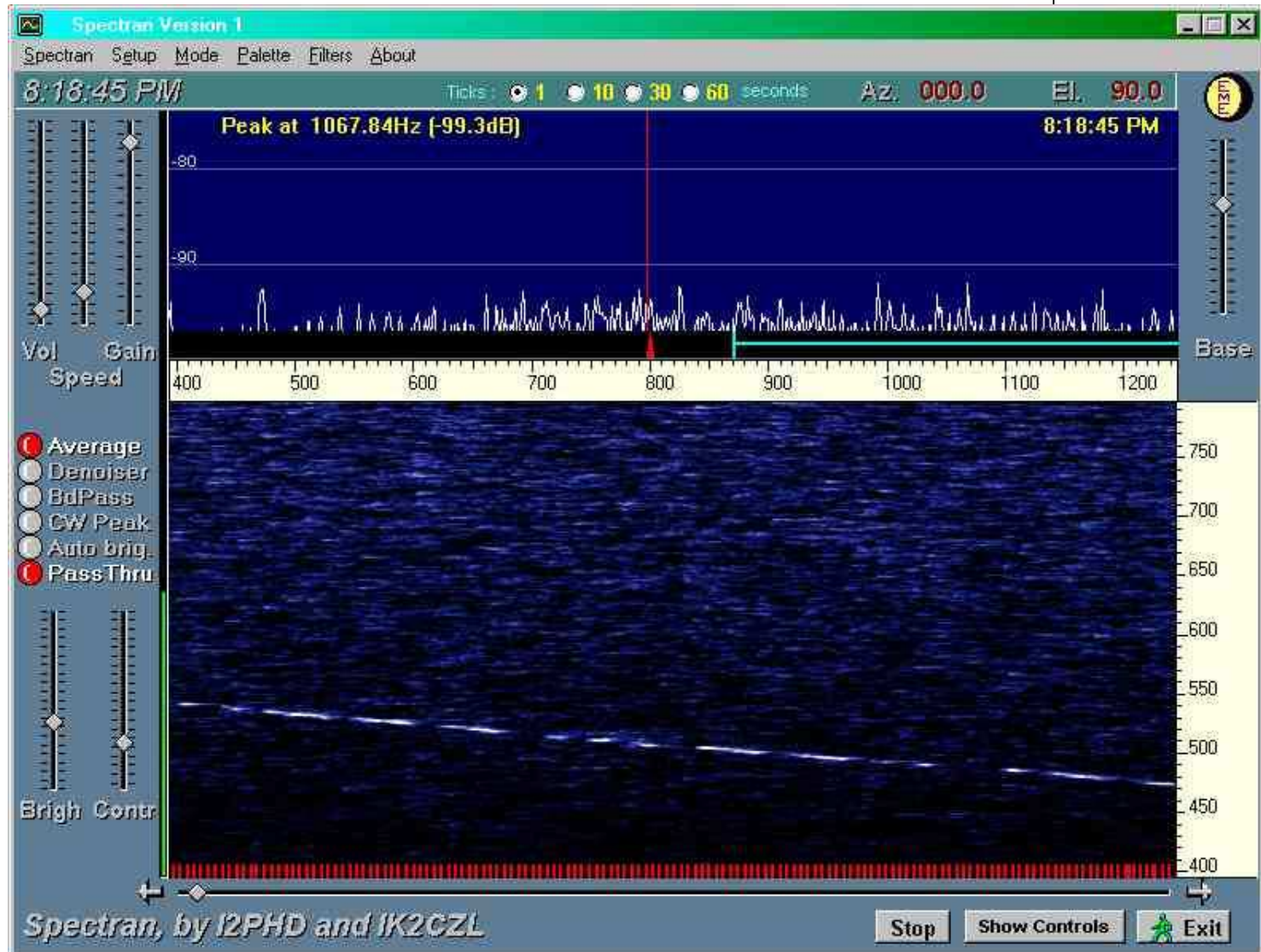
Software Defined Radio (SDR)

- Very popular use of soundcard is as general-purpose AD and DA converters.
- Left channel and Right channel become the I and Q channels.
- Soundcard is not designed as a general purpose AD and DA converter.
  - Soundcards vary widely – performance concerns <u>must</u> be considered.
  - I/O is AC-coupled.
  - Soundcard Performance impacts things like:
    - Real-time spectrum scope bandwidth
    - Dynamic range
    - Opposite sideband rejection

Dynamic Range

- For a perfectly linear ADC
  - Effective Number of Bits
    - (ENOB) = (SINAD$_{dB}$ − 1.76) / 6.02
- Noise voltage = $\sqrt{4kTBR}$
  - Room temperature, 100 KHz bandwidth, 50 ohms
    - $\rightarrow$ 0.28 microvolts RMS noise
  - Assume 2 volts peak-peak is maximum input level.
    - 0.707 volt RMS / 0.28 μV RMS = 127.9 dB dynamic range.
  - ENOB = (127.9 - 1.76) / 6.02 = 20.9 bits is useable.
- Therefore, ADC capable of >= 21 bits ENOB is needed
  - For 20 KHz BW, desired ENOB >= 22.1 bits

Real ADCs for Soundcards
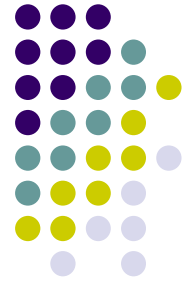
- Soundcards are not designed as a general purpose ADC / DAC card.
- Common issues:
  - Limited frequency response.
    - 20~70 Hertz high-pass (AC coupling).
    - ~20 kHz low-pass for audio (avoid aliasing).
    - ~80 kHz low-pass for 192 ksps soundcard (avoid aliasing).
  - Noise response not flat across passband.
  - DC error.
  - Amplitude and phase mismatch between the left and right channels.
  - A 24 bit ADC always has less than 24 ENOB.
    - Many 24 bit soundcards are 17-19 ENOB.
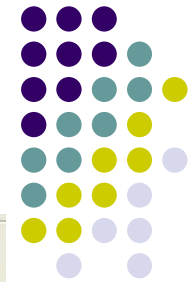
Some 24 bit ADC converters
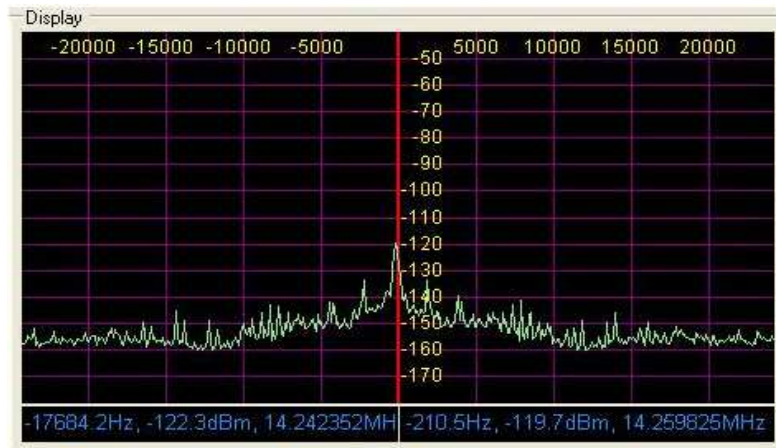
Figure 2 – WM8785 @ 48khz Sampling
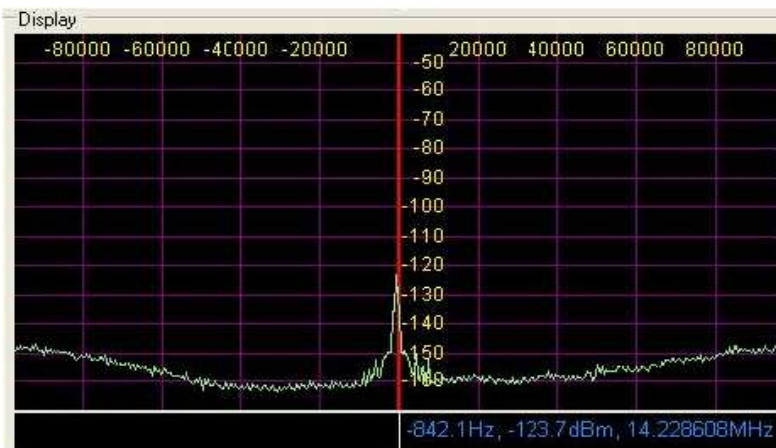
Figure 5 – TI PCM4202 @ 192khz Sampling

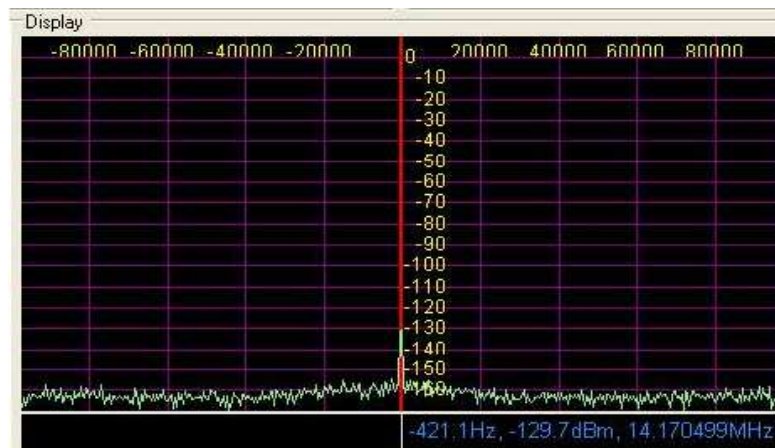Figure 4 – Wolfson WM8785 @ 192khz sampling rate

Figure 9 – AK5394A @ 192 khz Sampling

"Janus – a Sound Card designed for Software Defined Radios"
Phil Harman, VK6APH and Bill Tracey, KD5TFD, from TAPR.

Amplitude and Phase match

- For SDR – the image occupies half the spectrum (positive & negative frequencies are images).

- To achieve acceptable image rejection, left and right channels must be well-matched in amplitude and phase response.

- Amplitude matching better than ±0.005 dB and phase matching better than ±0.03 degrees is need for ~70 dB image rejection.

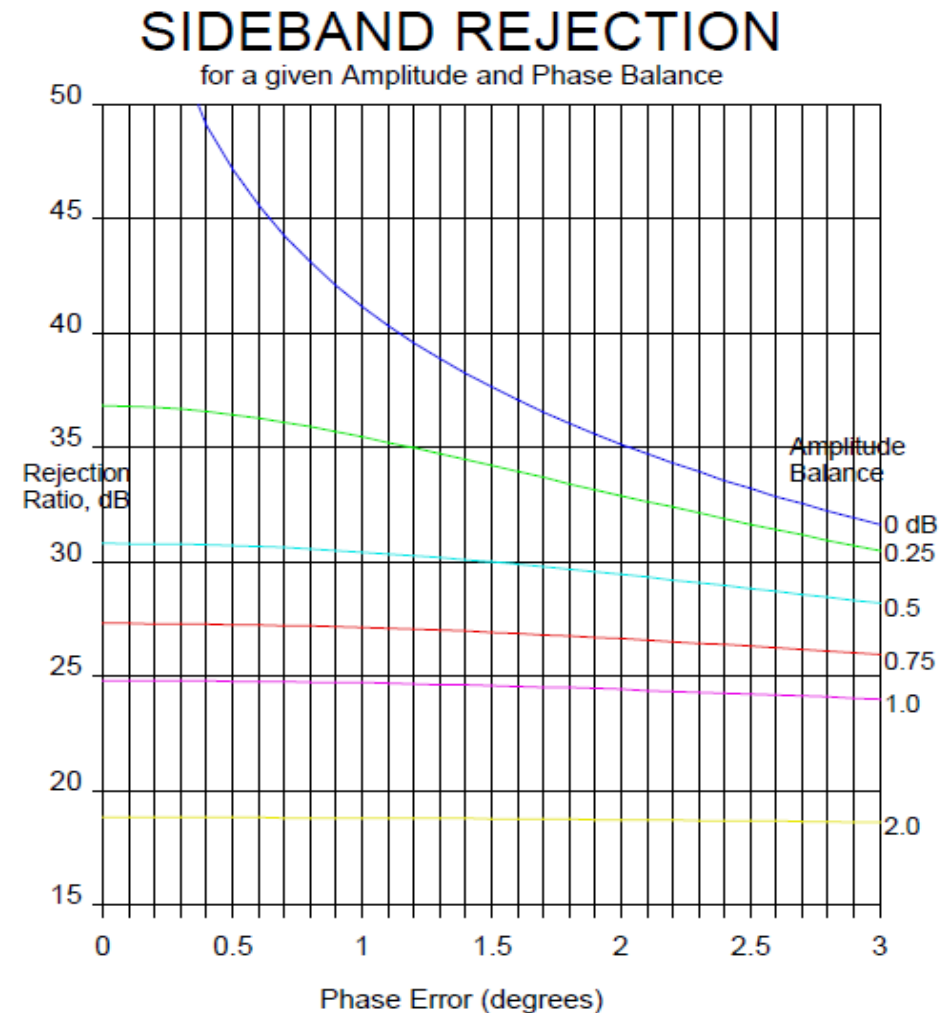- Typical soundcards are not this good across entire passband.

Figure from Merrimac Industries application note: " COMPLEX MODULATORS and DEMODULATORS (I & Q NETWORKS) 10 to 8,000 MHz GENERAL INFORMATION"

Some soundcard SDR results

(from LP-PAN test results[1])

	Noise Floor: Display Center	Noise Floor: Display Edges	Broadband Image Rejection	CPU Usage (Note 2) [A = best]	Application Sharing [A = best]	Cost New
192 kHz						
Creative Labs E-MU 0202 USB	-130dBm	-126dBm	55 - 80dB	C	B	$100
Creative Labs (Note 4) E-MU 1212m PCI	-138dBm	-138dBm	45 - 60dB	B	A	$140
Roland Edirol FA-66 Firewire *	-129dBm	(Note 3)	45 - 70dB	B	B	$280
Infrasonic Quartet PCI	-133dBm	-125dBm	50 - 70dB	B	A	$140
96 kHz						
M-Audio Firewire Audiophile	-131dBm	-131dBm	55 - 75dB	A	A	$80 Used
M-Audio Delta44 PCI *	-129dBm	-129dBm	50 - 70dB	A	A	$150
M-Audio Audiophile 2496 PCI	-131dBm	-131dBm	55 - 70dB	A	A	$90
SoundBlaster Audigy 2 ZS Notebook PCMCIA (Note 8)	-129dBm	-129dBm	55 - 70dB	A	?	$50-100 Used

[1]Larry Phipps, N8LP. See: http://www.telepostinc.com/soundcards.html for complete notes.

Resources

- Audacity is available (free) from Sourceforge.net: http://audacity.sourceforge.net/download/
- Links to many digital communication software packages: http://www.ac6v.com/software.htm#DIGITAL
- CWGet decoder: http://www.dxsoft.com/micwget.htm
- MMTTY RTTY program: http://mmhamsoft.amateur-radio.ca/mmtty/
- Audio clips of digital modes, links to some software: http://www.wb8nut.com/digital.html
- Spectran V2 spectrum analyzer software: http://www.sdrham.com/spectran.html
- LP-PAN SDR based panadaptor: http://www.telepostinc.com/