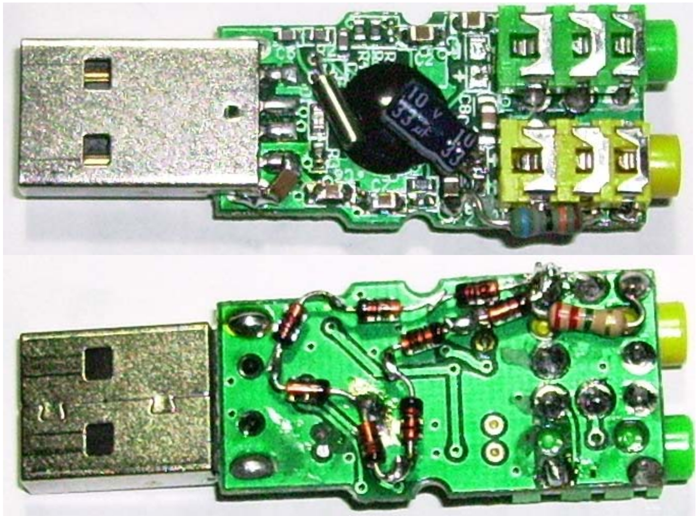
This article describes modifications to common cheap external USB connected soundcards to make them suitable for use with oscilloscope and spectrum analysis software for audio bandwidth applications. The cheapest devices appear to be based on the CM108 or CM119 controller with 16-bit ADC (microphone) input and 16-bit DAC (headphone) stereo output. The frequency range of the MIC input can be made from DC to about 20kHz (related to 44kHz USB sampling rate), although the simplest mod described here remains AC coupled and so extends down to about 5-20Hz.

Software known to be useful are Room EQ Wizard - REW 5.1, Virtual Analyzer, and TrueRTA (simple and easy to use but costs). Software like REW is powerful and free, but can take some learning and doesn't include an oscilloscope function.

'3D SOUND' USB soundcard



$1.00 on eBay. Simple stereo output soundcard, with mono microphone input, based on CM108 chip.

MIC socket input is mono, with phantom MIC powering via 4.5VDC to socket from chip bias supply, and then 100nF coupling cap to CM108 MICIN pin. Modifications made:
- remove 1.2k smt connecting to MIC socket tip/ring, to remove phantom powering from tip.
- cut off ring terminal between socket and pcb, so only tip and base connected on MIC socket.
- add a 2M2 from tip to 0V to keep coupling cap grounded.
- add 680k in series between ADC 'MICIN' coupling cap to MIC socket tip. The MIC socket input impedance is increased to ~900kΩ.

Effective ADC input resistance determined by firstly checking when clipping starts with direct input (2.8Vpp ADC input, 1.0Vrms), with MIC recording level set to 0% to stop any gain settings. Then add a resistor in series to the MIC input to give an attenuator – with 680kΩ added, the new input level for clipping is ~4.2Vrms, so the divider ratio is ~4.2 : 1, and hence the effective ADC input resistance is ~210kΩ.

Headphone socket has 2.2VDC bias because decoupling caps weren't installed (0R smt links were used by manufacturer). Modifications removed 0R links for Left and right outputs, and added 33uF 10V coupling cap for Right output. So only right (tip) line output connected to headphone socket.

The soundcard is not shielded, so locate away from switchmode flouro bulbs and mains power LED lights.

PC setup

Connect a loopback cable between soundcard Headphone socket and MIC socket. Set TrueRTA generator off, and set Windows Recording to 'no AGC' and adjust level so that no further reduction in level will lower the noise floor level at the 20kHz end of the spectrum [50% level on my PC]. Change Windows Recording between 16bit 44kHz sampling, and 48kHz sampling, and choose setting with least artefacts [48kHz showed peaks above 10kHz on my spectrum].

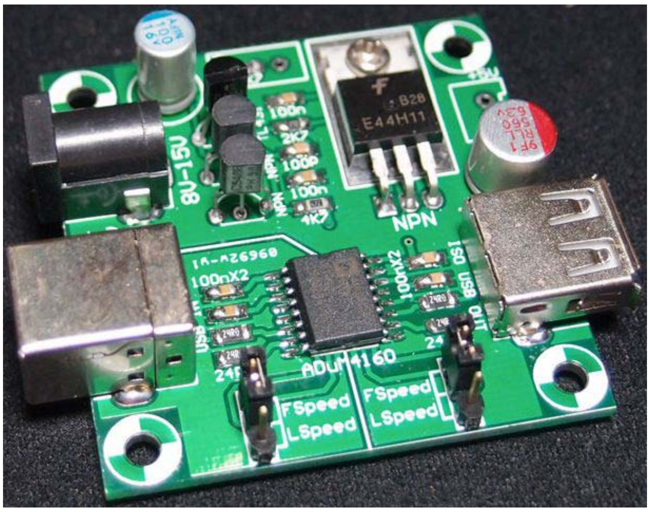
Turn on the TrueRTA generator and set Ampl to 0 dBu and 1kHz sine. Set Windows Playback to disable all enhancements, and set level at 100%. Check the relative difference between 1kHz fundamental and harmonics as TrueRTA Ampl is raised and lowered – the best SNR for me was at -1dBu.

Reduce Windows Recording level to 0% and adjust input signal to just below soundcard clipping level (4.2Vrms). Then increase Windows Recording level to just below where soundcard clipping occurs [10% on my PC]. This gives maximum signal span.

Check for any parasitic signals in plots - parasitic signals may occur due to USB communications processes. Disconnecting the soundcard LED, and adding an additional bypass smt cap to the chip (rear of pcb), had no effect on performance.

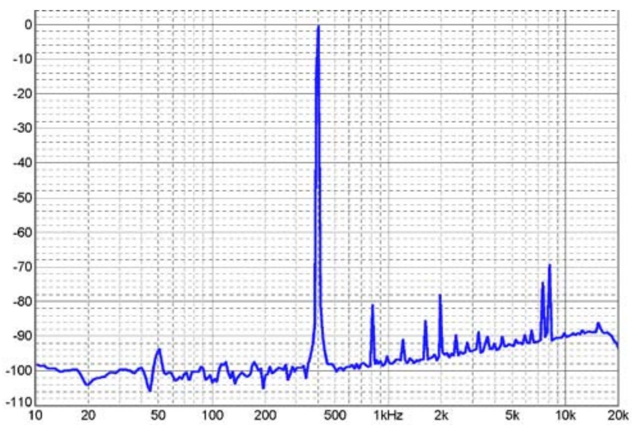
USB optical isolator

An ADuM4160 based isolator board (ebay $26.50 delivered) minimises ground-loop related signals, and provides galvanic isolation to avoid high current ground transients that could accidently damage soundcard and parts of connected computer. The Analog Devices ADuM4160 has links set for full speed USB 2.0 compatible operation. A USB A to B lead connects isolator host socket to computer. USB soundcard connects to isolated power side of isolator. A 12V battery can be used to power the 8-15VDC input to a linear reg on the isolator board, which generates 5VDC to power the USB soundcard.



Soundcard Performance

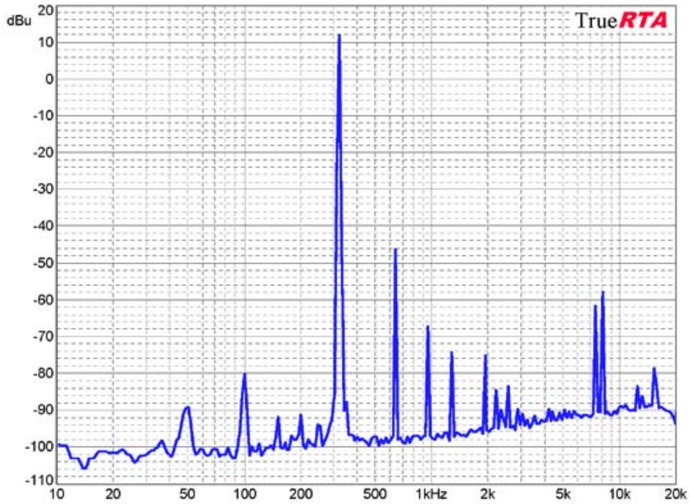
Loopback connection from Line-out to MIC input on soundcard (44kHz sampling), with TrueRTA generator disabled, and set for a 1Vrms line-out signal (just before clipping of Line out generator). USB isolator powered from battery. Parasitic signals at about 8kHz. Harmonics at about -80dBu. Some insignificant 50Hz signal above noise floor at about -90 to -100dBu. Noise-floor rises with frequency and then drops as approx 15-20kHz bandwidth from sampling rate kicks in.



External TMC oscillator input to MIC socket.

4.2Vrms input showing 2nd harmonic at about -58dBu.

ADC clipping ramps up harmonics rapidly above 4.2Vrms (12Vpk-pk), so 4.3:1 divider ratio (effective ADC impedance about 230k, and then has 2M2 in parallel to give 207k impedance).



Soundcard signal over-voltage protection.

Many applications can apply substantial overvoltage stress to the soundcard MIC input, and damage the your $1 investment ! This section discusses two on-board mods for protection: diode shunting, and diode clipping to supply rails. Note that some applications are benign, with no need for extra protection circuitry, such as a direct guitar input, or input from a soundcard preamp circuit with 5V rail swing limiting included.

For a simple 4-series diode per polarity protection setup, where 1N4148 diode strings shunt the 680k/coupling cap node to 0V, the diodes present a loading proportional to voltage.

An input voltage of 1Vrms (1.4Vpk) gives a nominal 1.4V/4.3 = 0.33Vpk at the node. The peak diode voltage is then 0.33/4 = 0.08V, which presents an impedance across the node of much more than 4x 250k = 1M.

The 1Vrms loop-back results below show no effect of diodes (50Hz signal may be aberrant).

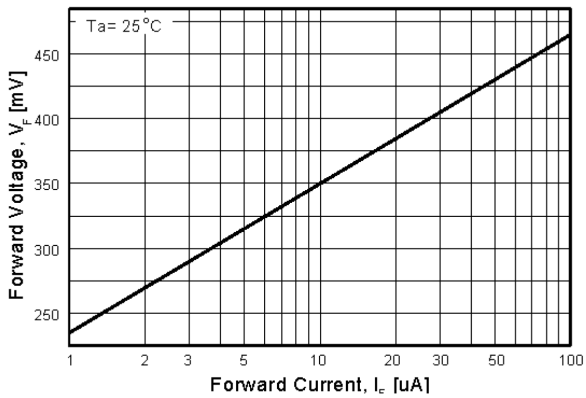
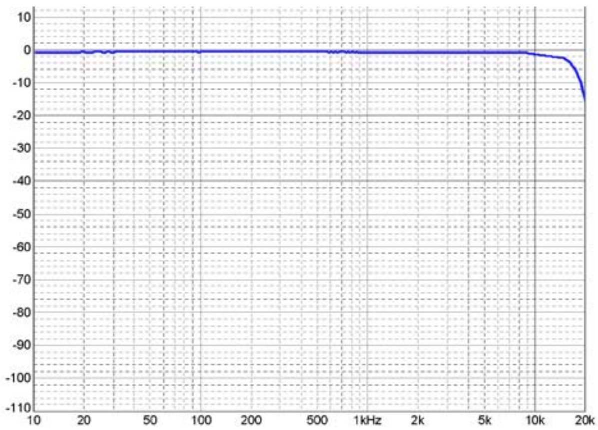
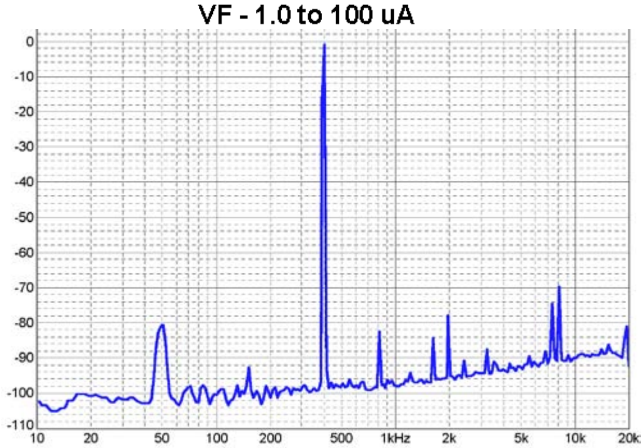
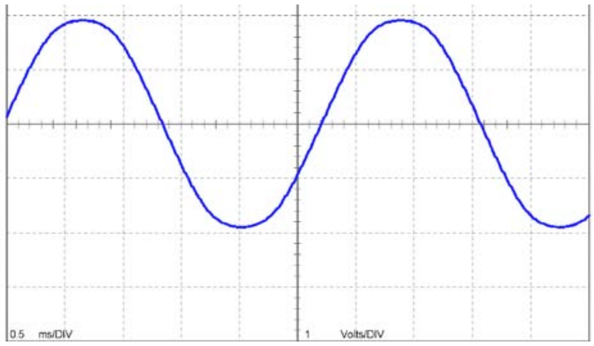


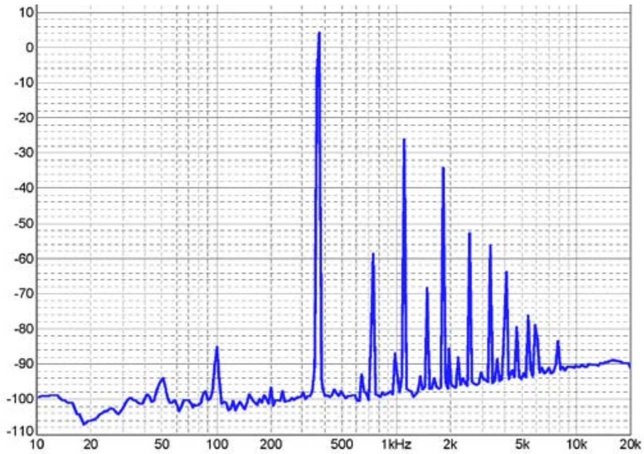
Figure 3. Forward Voltage vs Forward Current VF - 1.0 to 100 uA

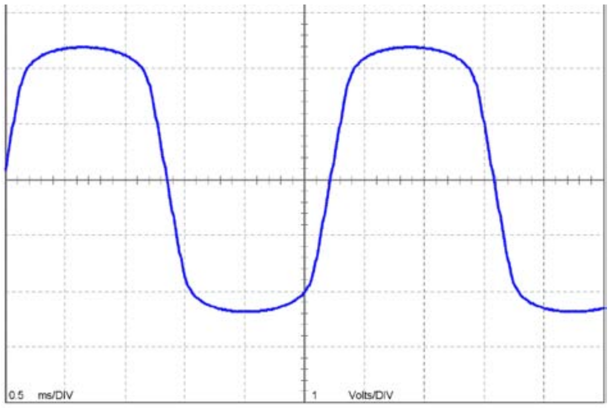


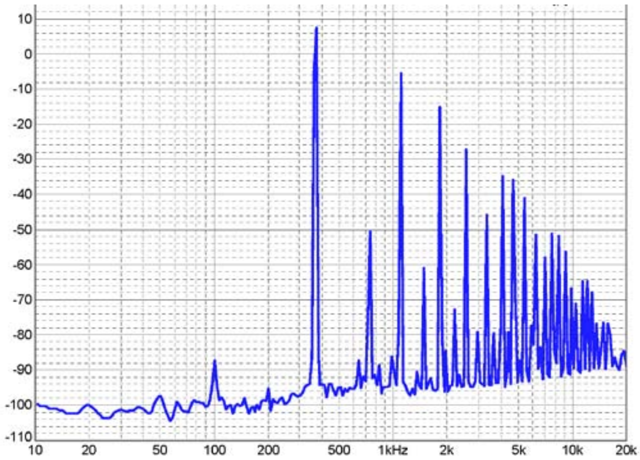


The results below are for 2Vrms and 3Vrms levels from a TMC oscillator. The 3Vrms input level shows substantial soft clipping above an ADC input voltage of about 0.7Vpk (the scale is about 0.35Vpk/div), which indicates diode current may only be peaking near 1uA. Although there are exotic (and expensive!) diodes with low leakage of 1uA at 0.53V (eg. FJH1101), and a few diodes (eg. BAV199) with perhaps slightly better specs than 1N4148, this protection scheme is quite limiting on voltage span performance.

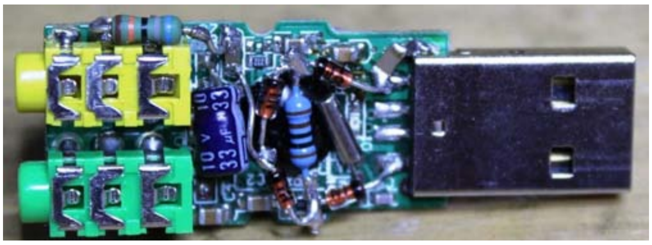


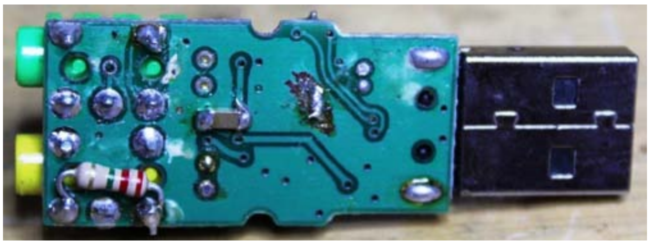




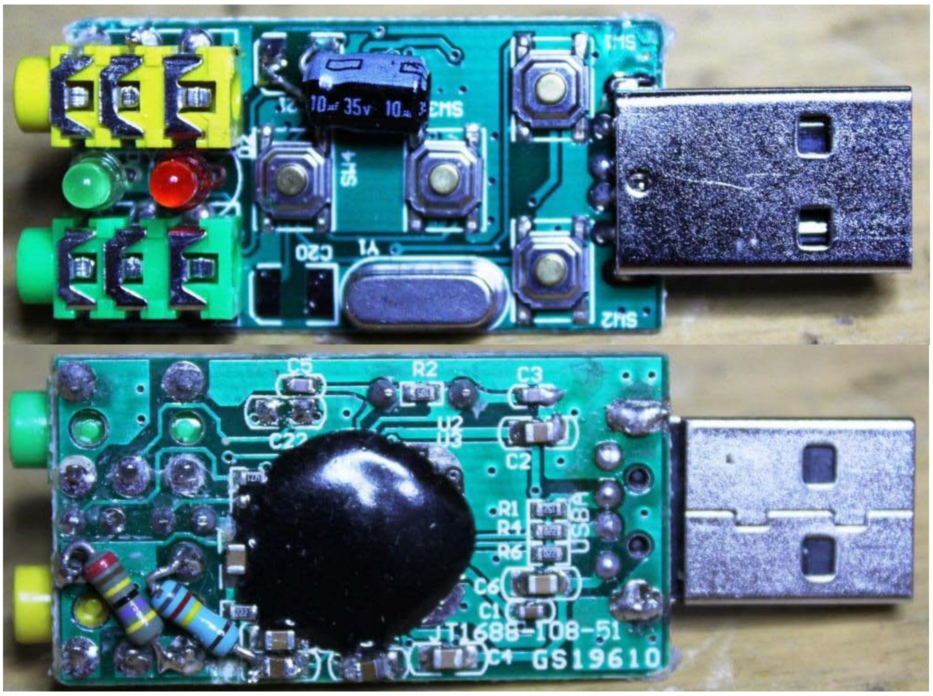


An alternative for protection is to clamp the input signal through a diode to the USB 5V supply rail, and a diode to ground. That form of protection may still cause damage as the absolute voltage spec for CM108/119 is -0.3 to +5.5V. A soft clip circuit is shown below that uses clamp voltages of about +0.7V and +4.3V, with the MICIN pin voltage rising about 1V beyond the soft clamp levels for about 0.3mA of clamping current, which would nominally require a signal input level of about 0.3mA x 680k = 200Vpk. Of course the signal input should be restricted to a nominal 5Vrms max level, but should survive moderate levels of transient stress (the ceramic smt cap will have a relatively low voltage rating).

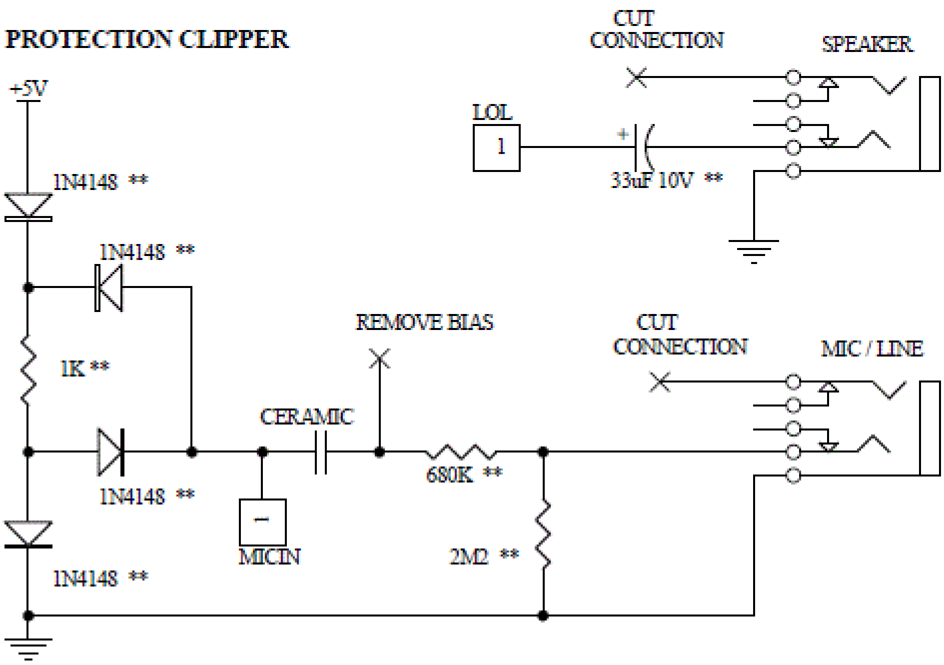




'3D Sound' soundcard with soft-clip circuit modifications as shown in schematic below.



'7.1 Channel Sound' virtual soundcard with just the basic modifications shown in schematic below (no protection clipper parts). The circuitry appears to be fairly similar to the '3D Sound' device, and is modified in the same manner.



Generic CM108/CM119 soundcard modifications (** are added parts)