generation of binaries is only possible in the professional version. In the 'Build Configurations' menu (accessible from the main menu under 'Project') make sure that 'Set Active' has been selected in 'Debug'. Otherwise new or modified programs will not be transferred to the controller for debugging.
Now there's no reason why you can't start thinking up your own applications for this powerful system. A good starting point for those new to the environment is the examples posted on the STM32-Discovery website [4]. Running through these will quickly boost your confidence with the system. The downloadable data describes the board in detail (circuit diagram, pinouts and jumpers). STMicroelectronics have indicated that the website will be active by the 15th September at the latest.

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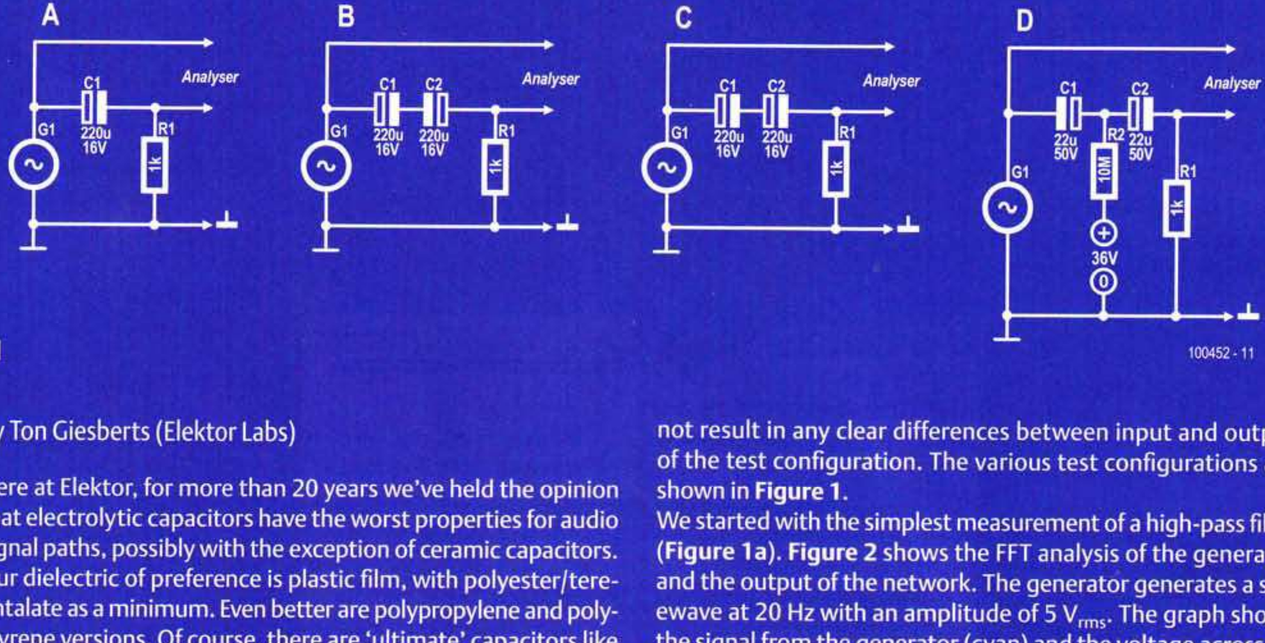
[1] www.st.com/mcu/inchtml-pages-stm32.html
[2] www.st.com/mcu/familiesdocs-110.html (the last one in the list)
[3] www.atollic.com/index.php/download/downloadstm32
[4] www.st.com/stm32-discovery

Electrolytic capacitors in audio circuits



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By Ton Giesberts (Elektor Labs)

Here at Elektor, for more than 20 years we've held the opinion that electrolytic capacitors have the worst properties for audio signal paths, possibly with the exception of ceramic capacitors. Our dielectric of preference is plastic film, with polyester/terephtalate as a minimum. Even better are polypropylene and polystyrene versions. Of course, there are 'ultimate' capacitors like Teflon or silver-mica devices, but we're talking about electrolytic caps here.

Electrolytic capacitors are commonly used as coupling devices in valve amplifiers, but we also frequently find them in solid-state amplifiers. The advantage of electrolytic capacitors is their large capacitance to volume ratio. In the original design of the '5532 Power Amplifier' (first part of this edition), two electrolytic capacitors were used, which we eliminated in the final design; a DC control is added instead to compensate for any offset. In this way any discussion as to whether electrolytic capacitors have an audible effect on the sound, in whatever way, can be avoided. Nevertheless we were curious what the effect of the electrolytic capacitors would have been if we had left them in the signal path. We will show the results of the THD measurements, tests with MLS and standard IMD signals did not result in any clear differences between input and output of the test configuration. The various test configurations are shown in **Figure 1**.
We started with the simplest measurement of a high-pass filter (**Figure 1a**). **Figure 2** shows the FFT analysis of the generator and the output of the network. The generator generates a sinewave at 20 Hz with an amplitude of 5 V_{rms}. The graph shows the signal from the generator (cyan) and the voltage across R1 (green). There is therefore an increase in distortion, but the harmonics are below –120 dB! In reality they are even lower, because they are only a little stronger than the harmonics from the generator, which are at –130 dB (2nd and 3rd harmonics). Expressed as a percentage the distortion increased from about 0.00017 % to 0.00023 %. The measurement was repeated for other types of 220-µF electrolytic capacitors. Next was a non-polarised electrolytic. It came as a surprise that the comparison with the generator signal shows practically no difference. This was followed by the two different types of electrolytic cap from the first measurement, this time connected in series in a bipolar manner (**Figure 1b**). There still was practically no difference to be seen between input and output. To find out whether the polarity made a difference, we turned the second electrolytic around (**Figure 1c**); the measurement across R1 now showed two harmonics which were a few dB larger than the measure-

ment with one electrolytic. We can therefore conclude that a bipolar configuration, with respect to distortion, is preferable over a single electrolytic. We assume that the non-linearities are cancelling each other. We followed this with measurements using other electrolytics (different manufacturers and rated voltages). The results gave different pictures, but always an increase in distortion. In all these situations a bipolar connection had a positive effect.
After this we did tests with electrolytic capacitors that were 10 times smaller. The corner frequency is now at 7 Hz instead of 0.7 Hz with the 220 µF device. There is now a greater voltage drop across the capacitor. The result of a measurement using the configuration of **Figure 1a** at 20 Hz (5 V_{rms}) can be seen in **Figure 3**. There is now considerably more distortion (about 0.005 %), and that is only due to the electrolytic! We also tried a bipolar connection, which gave a chart with a second harmonic that was about 17 dB lower, but the third was a little bigger. The rounded distortion figure remains the same.

We had one remaining question. Does the DC voltage across an electrolytic capacitor have an effect on the distortion? That is why we carried out a measurement according to **Figure 1d**. We don't have to show the result, because the two curves (with and without DC voltage) are practically on top of each other.

To get a feel for the quality of standard plastic film capacitors (Siemens/Philips 'MKT') we did two more tests with two versions of the high-pass filter with a corner frequency of 20 Hz. The first version was a large 4.7 µF/250 V capacitor and a 1.69-kΩ resistor. The second version was a cheap 2.2 µF/100 V capacitor (type without plastic case) and a 3.65-kΩ resistor. The results of the measurements are shown in **Figure 4**. Both versions gave pretty much the same result. Only the 2[nd] harmonic increased by 12 dB and the third remained practically identical.

From these tests we can conclude that when using electrolytic capacitors in the audio signal path it is desirable to locate the corner frequency well below the desired audio range. In cases where the impedances are low (kilo-ohms) there is no real alternative to electrolytics for blocking potential DC voltages. The disadvantage of the large capacitance is that a change in DC voltage will still be partially allowed to pass, because of the long time constants involved. Switch-on phenomena also last longer. A consideration can be to increase the impedance (results in more noise), so that it is still possible to use a polyester (MKT) device. The advantage is then that the polyester cap can be dimensioned for the desired corner frequency.

From this we can conclude that when using electrolytic capacitors as coupling capacitors there is practically no measurable effect on the audio signal provided that the capacitor is considerably over-dimensioned. With these 'too large' electrolytics it is also beneficial to use them in a bipolar connection.
We have looked here at only one aspect (harmonic distortion). There are obviously many more characteristics of electrolytic capacitors that could have an 'audible' influence on the sound quality.
Here is an overview of interesting publications if you would like more information about capacitors.

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Literature and Internet links

Capacitors in A.F. Circuits, Elektor February 1992

A real-time signal test for capacitor quality, The Audio Amateur, April 1985

Capacitor Sounds, Electronics World, July 2002 – January 2003

Picking Capacitors, Audio Magazine, February 1980

http://sound.westhost.com/articles/capacitors.htm

http://www.national.com/rap/Application/0,1570,28,00.html

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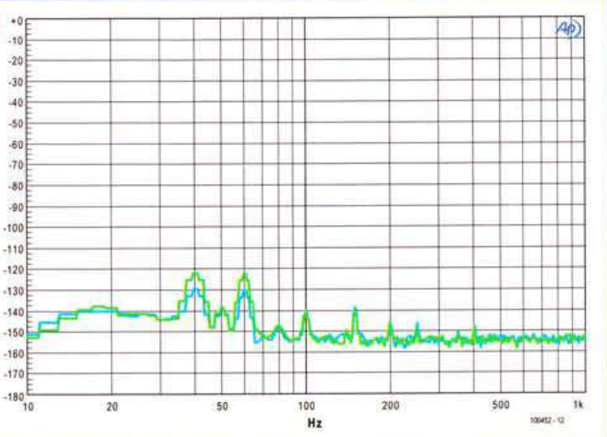

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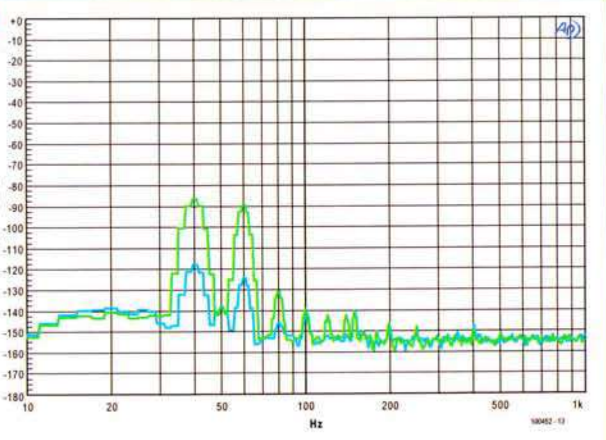

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