Application Note

Product: Minirator MR1
Subject: Square Wave Signal

This application note describes the technical details and application examples of the square wave signal produced by the Minirator MR1.

The Minirator MR1 is a professional, multifunctional analog audio signal generator , which covers most of the typical test signals used in a professional audio environment:

- Sinusoidal Signal, 20 Hz - 20 kHz,
- Frequency Sweep, 20 Hz - 20 kHz
- Square Signal, 20 Hz - 5 kHz
- White Noise
- Pink Noise
- Polarity Test Signal

The square signal is subject to detailed investigation in this paper.

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1. Frequently asked questions

Here are some frequently asked questions about the square wave signal.

1. Which benefit can I make from the square wave test signal ?

2. I connected the Minirator to an oscilloscope and selected a 5 kHz square wave at the Minirator. Looking at the generated signal I realized some ripple. Is this o.k. or is there some damage of the Minirator MR1 ?

3. I found the maximum square wave frequency to be 5kHz. On the other hand sin-signals up to 20 kHz can be generated. Why this restriction ?

4. I connected the Minirator to the Minilyzer and selected 20 Hz square wave. The Minilyzer scope screen showed sheared impulses. Why ?

The following sections will help to answer these questions.

2. What is a Square Wave Signal ?

A square wave is a periodic wave that alternately for a equal length (T) of time assumes one of two fixed values (+1,-1); the transition-time is neglectable in comparison to the time-length T.

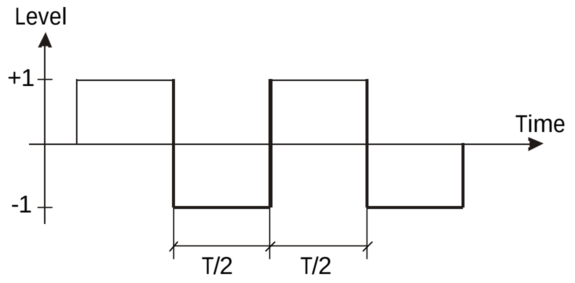

Fig 1, Ideal square wave signal

Analyzing the ideal square wave spectrum we recognize that it can be described as the sum of a infinity of frequencies including all uneven multiples into this sum (f, 3*f, 5*f, 7*f, ...n*f). Higher multiple frequency (n*f) do have a lower contribution to signal form. Real systems have only a limited bandwidth, since the available energy is limited. So teal square wave signals are approximations to the ideal one outlined above.

2. Applications

a. Acoustical testing

The square wave signal includes all uneven harmonics of the base frequency f (3*f, 5*f, 7*f, ...n*f) which are lower than 20 kHz. So many acoustic engineers like to use the square wave for acoustical testing. After getting familiar with the sound pattern of the square wave you may compare the actual sound pattern of your audio system acoustically with the familiar square wave pattern. Bigger distortions in the frequency spectrum are visible at a glance.

b. Power amplifier

Lets have a look into an analog power amplifier (PA), just one example out of a manifold of audio equipment by verifying roughly the 50% duty cycle and linearity of the square wave signal with the Minilyzer ML1, analog audio-signal analyzer of the same product family. Select for example a 400 Hz square wave at the Minirator MR1.

Test set up:

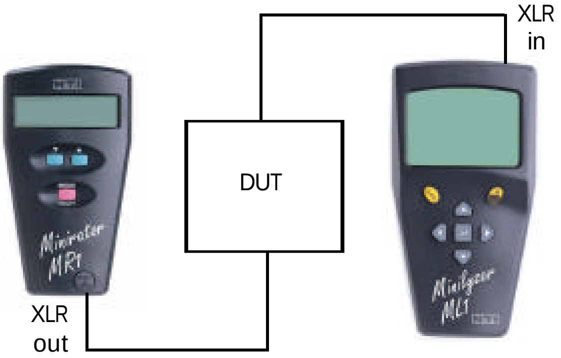

Fig 2, Test set up

3. Technical Details

Signal: Square Wave Signal with 50% duty cycle and no DC-offset

Frequency-range: 20 Hz - 5 kHz, selectable in 25 1/3rd octave steps

Level-range:			
	-76dBu	-	+6dBu
	-78dBV	-	+4dBV
	0.13mV	-	1.6V

The generated signal may be analyzed with the Minilyzer ML1. Simply plug the XLR-connector of the Minirator into the XLR-plug of the Minilyzer.

You may verify the below screenshots of the Minilyzer. The Minirator is adjusted to the square wave signal and the following frequencies:

f = 1 kHz:

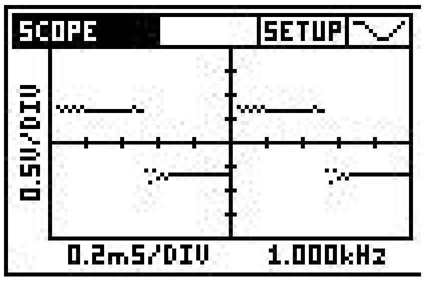

Fig 3, Screenshot Minilyzer, f=1 kHz

f = 5 kHz:

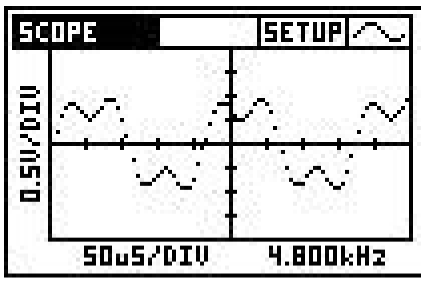

Fig 4, Screenshot Minilyzer, f=5 kHz

The sharpness of the generated square wave signal is decreasing at higher frequencies, due to the limitation of the audio band to max. 20 kHz. With the selected 5 kHz only the third harmonic frequency (15 kHz) is remaining in the audio spectrum. Therefore only a poor approximation to the square signal remains - a signal with noticeable ripple.

For higher frequencies (>5 kHz) even the third harmonics is out of the audio frequency spectrum (20 Hz - 20 kHz). Therefore the max. adjustable frequency for the square wave is 5 kHz.

f = 20 Hz :

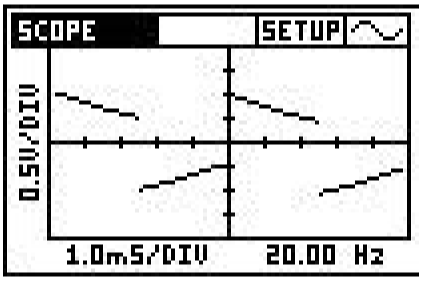

Fig 5, Screenshot Minilyzer, f=20 Hz

Please note the Minilyzer, like all audio devices, will show a square signal of low frequencies as the screenshot above. This is caused due to the internal input high pass filter of the Minilyzer ML1.

To get a 50% duty cycle of the square wave at higher frequencies, the actual generated frequency may vary from the displayed (1/3rd octave) frequencies:

So the following generated frequencies are different to the Minirator MR1 display indication.

MR1 display	actual generated frequency
2.50 kHz	2.40 kHz
3.15 kHz	3.00 kHz
5.00 kHz	4.80 kHz

Appendix:

Calculation of Square Wave Signal

To generate an ideal square wave signal an infinite frequency spectrum is required.

Mathematically the square signal can be calculated with the Fourier Transformation.

A square signal with the frequency f, depending on the time t, may be displayed as following:

$$f(t) = \sin(\omega t) + \sin(3*\omega t)/3 + \sin(5*\omega t)/5 + \ldots$$
$$\ldots + level(n*\omega t)/n$$

with $\omega = 2 * \pi * f$

e.g. f = 5 kHz =>

$$f(t) = \sin(\omega t) + \sin(3*\omega t)/3$$

Due to the limitation of the audio band to max. 20kHz the fifth harmonic of 5 kHz is already above the audio band, so only a distorted square signal with the third harmonic is produced.

This shows by reducing the frequency f , more harmonics of the audio band are included in the square wave and the signal quality is increasing accordingly.