Irreversible destruction of collected data with overgaining

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Introduction

Recently we have encountered a growing amount of GPR users asking for help with the interpretation of their data. Most of this requests were based on a presumption that a more skilled user will be able to interpret more out of the collected data. However, the problem was not in the lack of interpretation skills, but rather with the lack of data acquisition knowledge. Most of the data we received was heavily over-gained and clipped. By allowing the data to get clipped these users have lost part of the information which could in no way be retrieved. Except by redoing the survey.

This increasing confusion is a product of the constant marketing wars and deliberate misinterpretations of basic laws of physics and logic pushed by some sales departments. When approached by these sale strategies the non experienced users are baffled with images of over-gained data on the screen of the data acquisition unit. The problem is that the next step in the interpretation of this data is often left unexplained or poorly presented. This kind of sales tactics are questionable, but since this is one of the present problems we encounter, I will try to convince you to do otherwise.

> Data that has not been recorded properly can not be mended by any software trick or miracle data processing package. Over-gaining (clipping of the signal) is an irreversible process with guaranteed data losses.

What happens when you do it?

There are two significant problems that occur when you over-gain your data. The first one is obvious: clipping parts of the information at the receiver end. GPR receivers are made highly sensitive and can pick up very faint returning signals. These signals are then amplified and recorded. The problem occurs when a very high amplitude signal reaches the receiver. An amplifier can amplify the signals only to a certain maximum output value with a given linearity. After reaching the maximum output value the signal gets distorted. This results in dynamic range compression and amplitude compression of the signal. We say in these cases that the signal gets clipped.

Disregard to the signal-to-noise ratio is the second problem. Signal-to-noise ratio, often written S/N or SNR, is a measure of signal strength (meaningful information) relative to background noise (unwanted information) . The ratio is usually measured in decibels (dB). While the SNR is high there is a significant difference between the meaningful information and the noise, making it easy to interpret the data. However, if the SNR is low, at a certain point (threshold) the correct interpretation of the collected data will be impossible.

Before getting into the GPR explanation, let us look at the problem from a different perspective.

Imagine that you went to a symphony orchestra concert. The delicacy and richness of the sound produced by hundreds of different instruments have left you smitten. After you got home you are still thinking about the virtuoso playing the first violin....

...now let's color this experience with the horror of over-gaining. The sound crew did a lousy job and in the end just decided to crank the volume up. You were exposed to an explosion of drumbeats hitting your ears at all times and if it were not for the first violin carrying the melody you couldn't guess what they were playing. Except from the drumbeat and the violin you can just remember loud noise coming your way.

This is what happened:

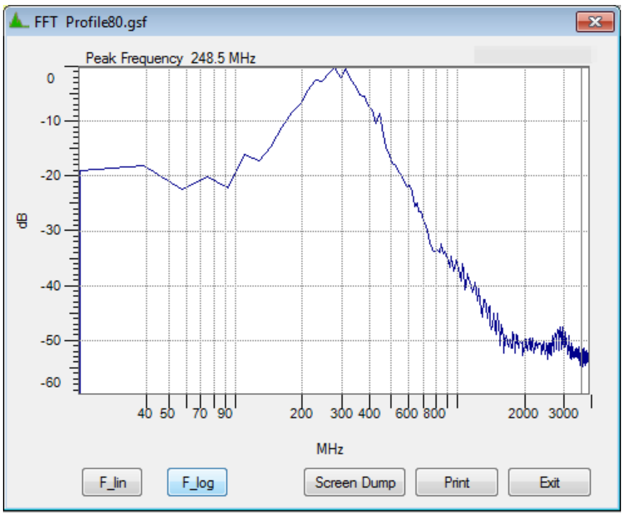
Your ears were a fine tuned receiver and while the levels of the sound were normal you could concentrate on each and every instrument. Therefore the entire experience was rich and pleasurable. However, when the sound levels went overboard – your ears tried to compensate by dismissing the loudness, and even got confused with the mixture of different loud sounds merged into one. Distorted and missing parts in the performance, the symphony orchestra now sounded like a poor punk-rock band.

Signal to noise ratio is even more trivial:

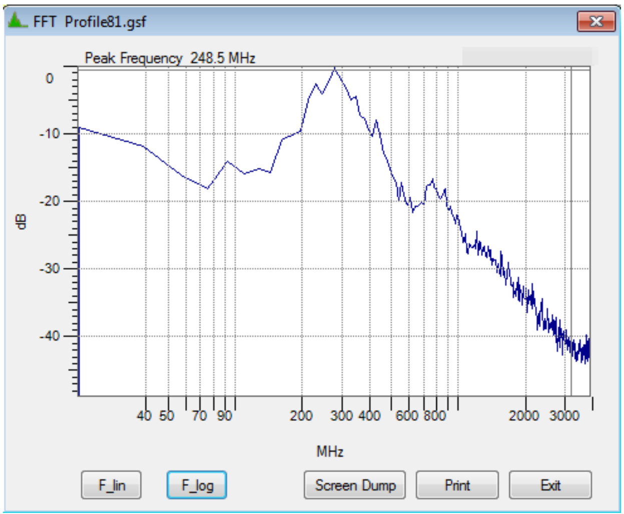
Imagine that you are listening to a TV (signal) and a radio (noise) at the same time. If the TV is significantly louder, you can apply simultaneous volume gain to both of them,and still be able to understand the louder source. However if the two sources are very near in sound levels they will get blurred and meshed into one sound. No matter what volume gain you use, you will hear them both, but will not be able to understand neither of them.

The same two problems viewed in the GPR world look like this:

A simple comparison of frequency spectrum between the normal gained data and over-gained data says it all. One can see the significant narrowing of the -10dB bandwidth and the increase of the high and low frequency noise component. Although collected with the same system (radar unit and antenna) the influence of our settings makes them two data collections entirely different.

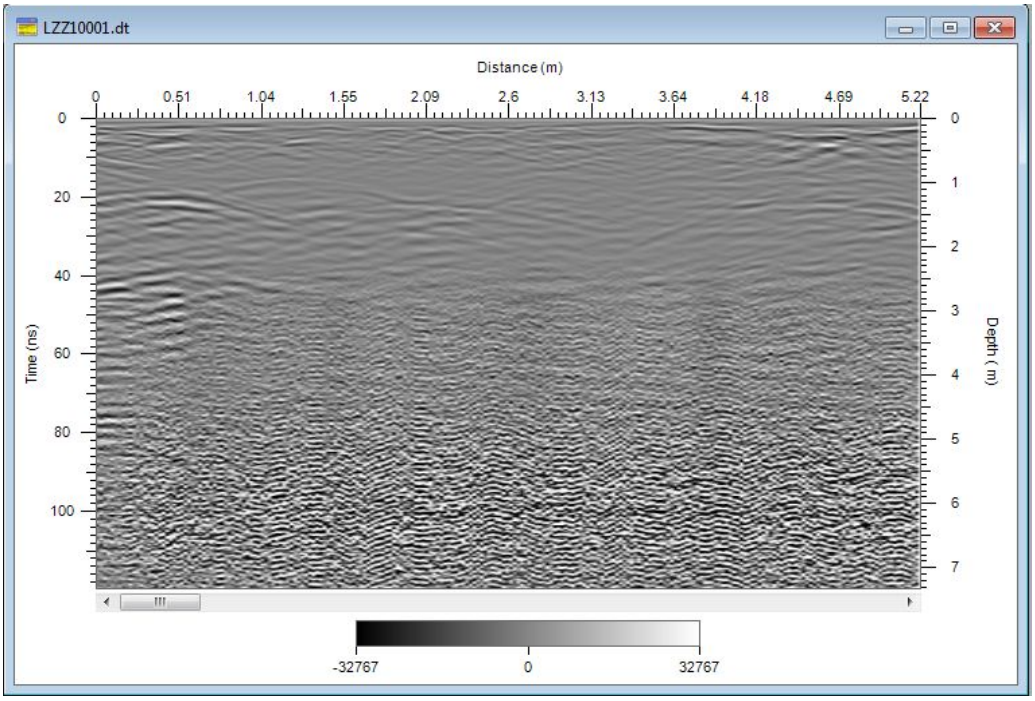


Normal gained data



Over-gained data

Signal to noise ratio problem can easily be explained as the point where your useful signal (let's say a reflection from an object) is so highly attenuated by the material that it has the same level as the surrounding EM noise. If you apply gain to this sort of data you are in no way able to discriminate if you are gaining the reflected signal or the noise (their level is the same). The resulting image is a merge of noise and signal and in some cases can be quite spectacular – this can lead to wrong interpretation conclusions.

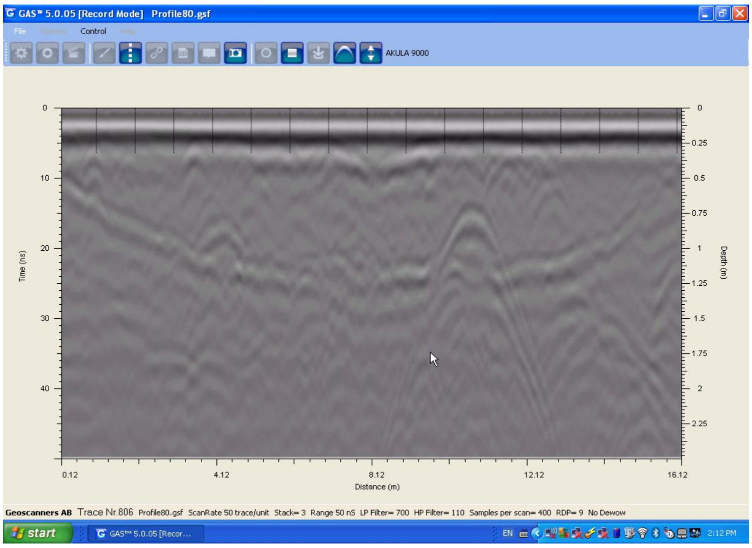


Fake vertical occurrences due to the gain distortion

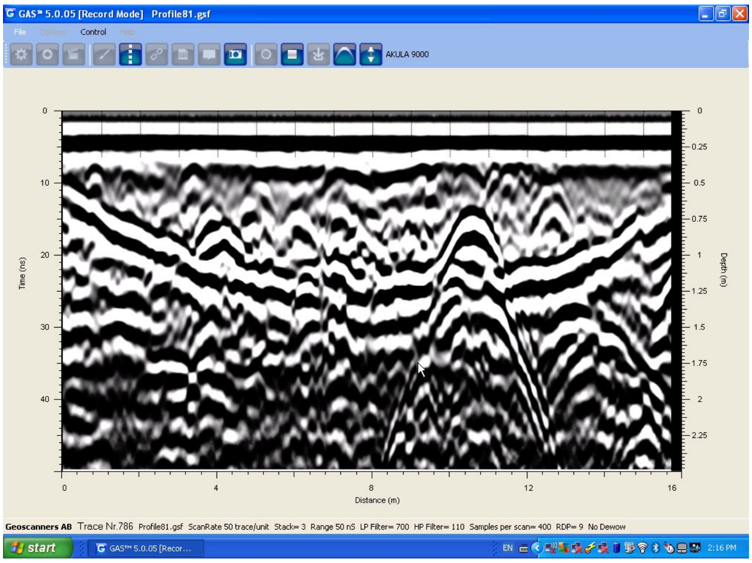
Conducting the survey

In this final step we will show you the actual testing data and the effect of over-gaining.
We collected two profiles over the same survey line. First profile was set with reasonable gain values and for the second one we did our best to over-gain it.

In the data collecting phase it was a bit easier to see the results on the screen with over-gained data.....

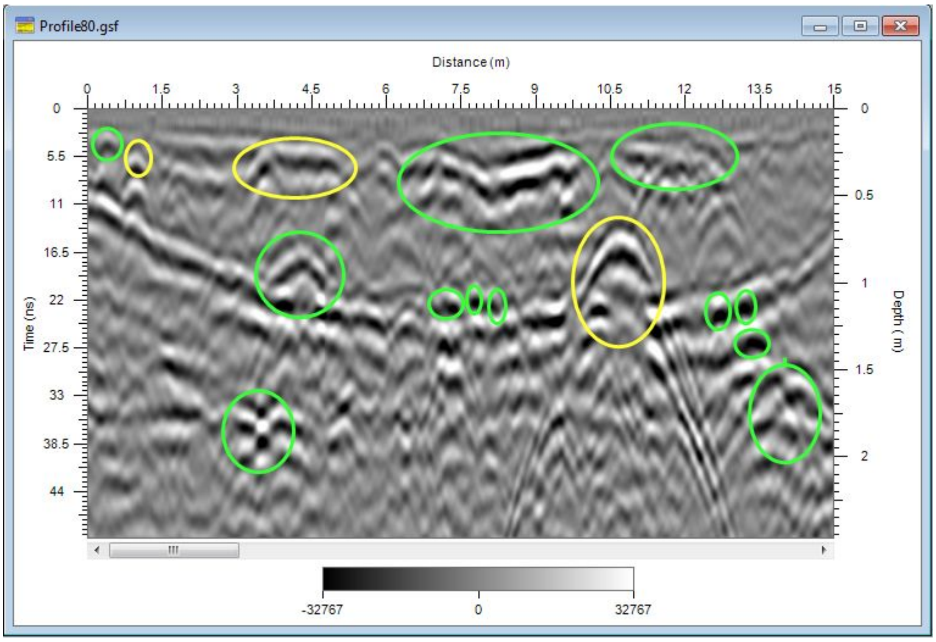


Normal gained data

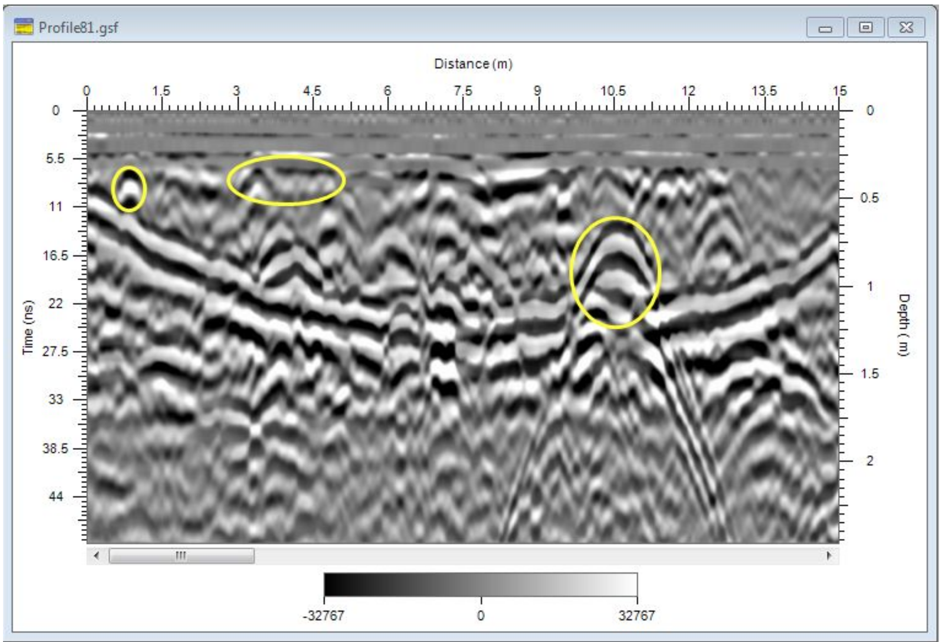


Over-gained data

...but when it comes to post processing and interpreting **the entire data** collected, the over-gained file was no match for the normal one.



Normal gained data processed and interpreted



Over-gained data processed and interpreted