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SHORT L_{eq} REVISITED

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1. INTRODUCTION

The technique of "Short L_{eq}", first introduced as a practical reality at the International Congress on Acoustics in 1983 is now more than a decade old. The technique has it's origins in one of the oldest methods of acoustic measuring, 'outbox' processing where, if an important measurement was required to be taken, a tape recorder was used to record the actual noise for replay in the laboratory. The disadvantages of this method are well known and do not need repeating.

When Komorn and Luquet wrote their now famous paper in 1979, *(ref 1)* and Commins used the Short L_{eq} technique in aircraft noise measurements, little did they realize that within 15 years, their ideas would become the de-facto method for computerised noise measurements. Their technique was devised as a method of compressing the data, ensuring it's integrity and yet storing a true representation of the original noise, the essential elements for a computer based system.

The method proposed was to integrate the sound level over a short period, typically under 1 second and produce a non-time weighted L_{eq} for this short period. This "Short L_{eq}" would be stored and a further L_{eq} taken, with no gap between them, continuing with successive L_{eq}'s for the duration of the whole measuring period, however long it was. The advantage of the method, is that the L_{eq} is a true integral of the energy and thus accurately describes it for all statistical purposes. It is important for the method that sampled values of Sound Level are not used as these have already been integrated by an exponential integrator and thus the time weighted sound level values cannot be concatenated to form a single long L_{eq}.

To put numerical values on the technique, a memory store of 86,400 bytes, would allow 24 hour operation with 1 second L_{eq} values being stored. When the method was first described, the idea of putting 86 kilobytes of memory in a hand-held meter, was held to be a dream, as current desktop computers had a memory of only about 64K. Also of course, an 8 bit word cannot describe the whole acoustic range to a sensible resolution and therefore at least 16 bits were needed, doubling the memory size to 172K; even more of a dream.

As is now well known, in 1983 at ICA Paris, a group of engineers met and discussed the concept of making a truly commercial sound level meter based on this technique and a cooperative venture was started with funding from both the French and British governments. The result, as is now history, was the world's first practical Short L_{eq} meter, the Cirrus CRL 236, making the concept of acoustic data storage a reality.

2. SHORT L_{eq} RATIONALE

While the original reasoning behind the concept was to store data in a compressed form, it is obvious that having stored the data on an external computer, that the same computer could also make the actual measurements. That is to say, the L_{eq} meter, can be used as a simple "dumb" acquisition unit. If this acquisition unit has adequate dynamic range, the only measuring task during acquisition is to place the L_{eq} meter in the correct place, to keep it secure and to ensure an adequate power supply. While this was the original concept, the last ten years have shown that, to be a commercial success, the L_{eq} meter must perform other more conventional tasks. The ideal however, is still that the Leq meter could integrate everything which could be measured by the microphone, which means that a dynamic span of around 120dB is required.

Originally, the data was simply copied to a desktop computer via its RS232 port and stored on the floppy or hard disk of the computer for subsequent processing. The original data is not destroyed nor modified in any way by the process of copying to the computer, which is very important as a safeguard against transfer errors. Now it is in digital form, as many identical copies of the raw data as required can be made and distributed for processing, which can be done on any suitable computer anywhere in the world; no longer does data have to be processed where it is acquired.

3. CURRENT USAGE

Over the last few years, many companies have followed the lead given by Cirrus Research and produced instruments which store Short L_{eq}. Initially, almost every major competitor gave many reasons why the technique would not work, but today, almost all of them have developed their own units. Among reasons given was that 'Computers have no place in acoustics' and 'Short L_{eq} gives different answers to sound level', as well as the most ridiculous of all 'It isn't in a sound level meter standard'. In fact, all these arguments have been proven to be untrue and shown to be simply commercial arguments against a new technique. Today, there are three areas where the Short L_{eq} method is supreme. These are in generating the time history of the noise climate, in area monitoring, particularly around airports and for industrial dosimetry. A fourth application, which was expected to be the most general (*ref 2*), is that of environmental noise measurement. However, while in France the Short L_{eq} technique is used extensively for this, in the UK and Germany, it is somewhat less so. The reason is not hard to find, being a combination of less than current electro-acoustic knowledge among some environmental engineers and the entrenched position of some established suppliers. If you have used a horse and cart for 30 years, it is difficult to accept the need to learn to drive a car. Even if you are persuaded to try the car, you are still likely to ask how much hay it eats and specify a certain type of horseshoe nail and bridle in any public tender document, especially if the suppliers of horses tell you how important the horseshoe nail and mahogany trim is to the correct measurement.

4. TIME HISTORY

Because each individual L_{eq} element is a measure only of the energy in the period, the simple display of the elements gives the true time history of the noise climate, with no lost data. Conversely, any use of exponentially integrated sound level, 'S', 'F' or 'I' has a large proportion of the signal determined by the time constant of rectification, or time weighting. Thus for example, a sudden impulse will not be recorded 'correctly' by sampling sound level. By 'correctly' we mean that the output is a true energy representation of the noise energy. Indeed, with sound level sampling, both the sampling speed and the time weighting can both be used to get different answers for the time history, as was readily done with the old 'high speed level recorder'.

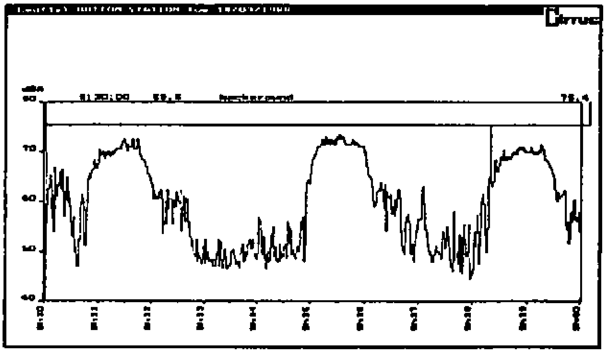

Figure 1: A Time history from 1986

Also, concatenating adjacent elements with sound level sampling gives data which has no conventional acoustic meaning, but concatenating L_{eq} elements simply gives an L_{eq} for a different period. A typical time history from Short L_{eq} is shown in figure 1, a file taken in 1986, pre-dating files from any other commercial unit.

5. AREA MONITORING

Even while some companies were explaining why Short L_{eq} was such a 'poor idea', they were at the same time using the technique in area monitoring. Today, all new technology airport or other area monitors use the technique or a variation of it. The data compression given by Short L_{eq} allows the transmission of data down a phone line from many separate monitors at the same time. For example, at an airport, each one of say 20 monitoring heads can acquire Short L_{eq}, recognise each individual flight, calculate the statistical noise climate using several independent statistical measures and still transmit raw data down to the host computer in real time. Because of the data compression, conventional low cost desktop computers can display the time history of the noise climate in real time as well as updating the noise map of the area. For those acousticians still unsure of the benefits of the use of L_{eq}, both the host computer, or each individual noise monitor can calculate the current sound level in either 'F' or 'S' response as required.

6. DOSIMETRY

In the United States, dosimetry has been used for over 25 years for industrial noise measurement. In Europe however, industrial noise control has been done using the sound level meter and each continent could not see why 'their' method was so disliked by the other. In fact, one of the main reasons why Europe did not take to dosimeter was that while they gave a perfectly good measure of the total noise 'dose' they gave no indication as to when or how that dose was received. The USA method was perfectly good for finding offenders, but little use in diagnosing the problem; even in acoustics American lawyers set the measuring trend. For analysis rather than enforcement, what was required was a technique which allowed not only the total daily dose to be measured, but also gave a measure of when the levels were actually exceeded. The answer came with data logging dosimeters. The early devices stored much less than 1000 samples, which gave a best resolution of about a minute over a working day and missed many noise variations; totally inadequate for accurate diagnosis. The first high resolution dosimeter, the Cirrus CRL 700 series could store data every 62,5 milliseconds at its highest resolution or using a more conventional one second basis, could store data for well over 30 hours, almost four working days (*ref 3*). Again, when first produced, more traditional manufacturers gave every reason why this was not required, but now, in 1993, several manufacturers have followed the lead given by Cirrus. One of the more interesting points is that today, the main complaint against the new technology, is that not enough data is stored.

7. SOFTWARE

As the acquisition and measurement of data can be separated, the software which performs the actual measurement can become an integral part of the L_{eq} meter. However good the actual acquisition, it can be the software which determines the system performance. In this respect, the experience of Cirrus and its partners is probably greater than almost any other company, particularly those traditional companies who have seen in external computer processing, a threat to their established position. They have concentrated on ever more powerful and expensive instruments, mainly ignoring the computer. This process has continued to the situation where a conventional L_{eq} meter from one company costs far more than a family car when complete with it's modules, or eight times the cost of a good desktop computer. One argument with Short L_{eq} meters is that the software is a fundamental part of the instrument and if so, it is reasonable that at least the core of the program should be provided free, as without it the instrument cannot be used. For this reason, the data from Cirrus meters can be recovered using the 'free' computer terminal programs such as those in Microsoft Windows$_{tm}$ or the many shareware programs available. Using these, the data can be recovered and displayed using many proprietary databases and spreadsheets, where the power of the dedicated programs such as ACOUSTIC EDITOR, are not needed.

8. INTEGRATING WITH THE COMPUTER

In the last few years, the practical concept has developed of adding a digital converter card inside the computer and simply feeding the output of the microphone into this card; the computer then becomes a sound level meter. ARIA, introduced by 01dB in the late 1980's *(ref 4)* showed the way forward, being the world's first computer system to get full standards laboratory approval as a type 1 sound level meter. Today, as the cost of computers comes down and the power required to operate Digital Signal Processing chips reduces, it is clear that even the most complex frequency analysis can be done inside the computer. The same technology can also be used inside the sound level meter itself and 1993 saw the first sound level meter using the ARIA concept outside the computer, it will not be tha last!

This process will continue as DSP processors become better until the conventional analysers will probably disappear.

9. CONCLUSION

The last decade has seen a real revolution in noise measurement, with the despised computer taking the lead role in many measurements. In many fields of noise control today, it is inconceivable to make complex noise measurements without using a computer.

The technology developed, first by Cirrus, and now by many companies, allows the computer to become an integral part of the measuring process rather than a calculator at the end of the process.

10. REFERENCES

1. Komorn A & Luquet P. "Methods de description objective d'un environement acoustique" Report to the EEC April 1979 and Internoise 1981.

2. Wallis A. & Luquet P. "Noise control application of Short L_{eq}" Proc Internoise Munich Germany Aug 1985.

3. Wallis A. & Krug R. "A data storing dosimeter" Proc IOA Vol 11 part 9 Windermere U.K. pp101-106 Nov 1989

4. Wallis A. "Computers in acoustics" Proc Taiwan Acoustic Society Taipei Nov 1991