DEVELOPMENTS IN SOUND MEASUREMENT INSTRUMENTATION

The 10th anniversary of the Control of Noise at Work Regulations (2005) is a great opportunity to review what has happened in the development of sound level meters in recent years.

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The Sound Level Meter

The fundamental design of the sound level meter has not really changed. We're simply trying to make an objective and traceable measurement of the noise level, to allow us to assess environmental noise impact or potential damage to workers' hearing.

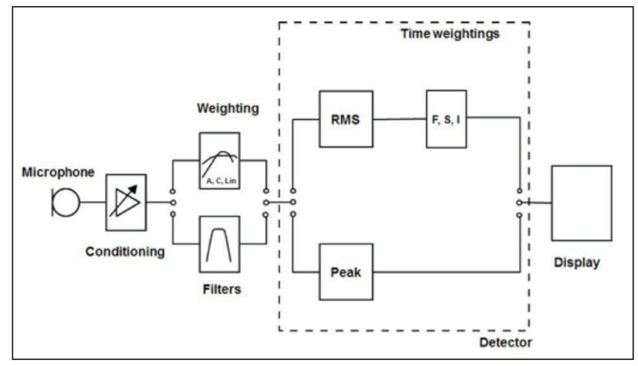


Figure 1

The building blocks of our meter are shown in **Figure 1**.

The starting point is the microphone, which transduces the acoustic pressure variation into a voltage analogue, which we can feed into our electronic circuits. Typically, we use a condenser type microphone, for its stability, linearity and ease of calibration. We need to polarise the capacitor, typically with 200 volts DC, and match its inconveniently high output impedance into something we can drive down the line.

Now we have a signal to work with, and two types of 'detector' are commonly used to make a measurement of sound pressure level.

The root mean square or RMS detector does what it says on the tin – backwards! Firstly the waveform is squared, making all the negative excursions positive, then this is averaged to estimate the power in the signal, and finally the square root is taken to get back to a number which is related to a pressure level.

The Peak detector simply measures the maximum excursion of the acoustic signal (either positive or negative) and this might be useful for estimating damage potential from the noise, such as from blasting or gun shots.

If we wanted to assess the noise level and not just the sound level, then there would also be frequency weighting circuits prior to the detector, A and C being the most popular, and for analysis of the frequency makeup of the signal, there may also be some filters, 1/1 octave or 1/3 octave being the most common.

The March of Digitisation

No-one today could have overlooked the fact that everything is going or has gone 'digital'. The sound level meter was no different, and the process started at the back end of the chain – the display. By sampling the output of the detector, albeit at the slow sample rates (~1Hz) available at that time, the values could be displayed with greater precision on a digital display, to the nearest 0.1dB, and the limited dynamic range of the A/D converters could be improved by doing the log conversion in the detector before sampling.

The next step was to sample the detector output at a higher rate, which allowed some basic mathematics to be done - calculating the average value of the signal over a time period. The idea of the equivalent continuous sound pressure level, or Leq, gained a foothold, and this was easily estimated by sampling the output of a Fast time-weighted detector. The first 'integrating sound level meters' had been born.

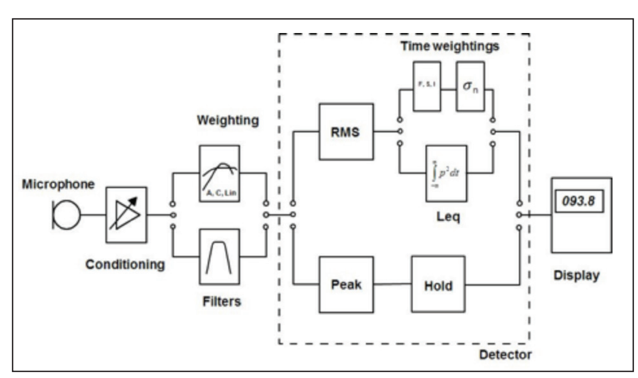


Figure 2

The new family of digital sound level meters now followed the layout of **Figure 2**, with the output of the detector being sampled at 256 Hz.

At the same time, the concept of Short Leq emerged, where the digital detector emitted Leq values over short periods. This was ideal for the new idea of datalogging, where complete measurements could be sampled and stored to memory.

The trend in SLM development by now had been a slow increase in sampling rate, and dynamic range. The advent of low power digital signal processing suddenly made it realistic to digitise the output of the microphone preamplifier directly, requiring a sample rate of over 48kHz. Our sound level meter still has to cover the complete range of human perception both in level and frequency, but now we can calculate weighting filters, 1/1 & 1/3 octaves, Leq and statistics completely digitally. The idea of digital dynamic range was no different to the old ways.

This simplifies our sound level meter down to **Figure 3**. Coupled with vastly increased memory, A/D converter and a DSP, almost anything is possible.

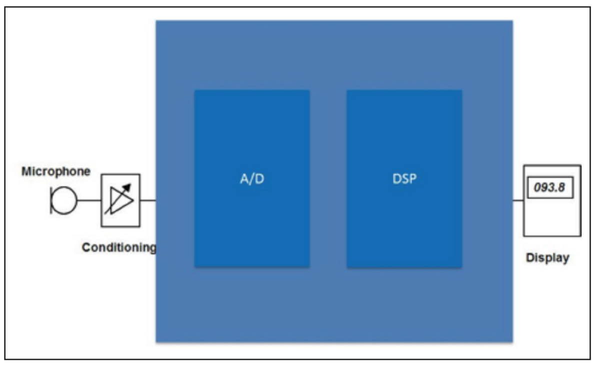


Figure 3

Svantek SVAN 971 Sound Level Meter

Completely Digital?

The microphone is the most costly part of a sound level meter and the last analog bastion in the measurement chain. Since precision sound level measurements began, the condenser microphone **(Figure 4)** has been the gold standard, the ½" capsule providing the best compromise in dynamic range and frequency range.

Figure 4

For other much larger markets, such as hearing aids and telephones, a digital revolution has been happening in microphone development. The use of MEMS (micro electro mechanical systems) or micro-machined silicon transducers is now well established.

MEMS microphones **(Figure 5)** are still based on the capacitor principle, but the capacitor is machined on to a tiny silicon wafer, which is packaged into a more manageable pot which can be directly soldered onto the circuit board. In some recent cases, the A/D converter can even be built in to the silicon, making what is effectively a digital microphone. MEMS microphones are also incredibly rugged, and of course, the low price of a few dollars is a real advantage.

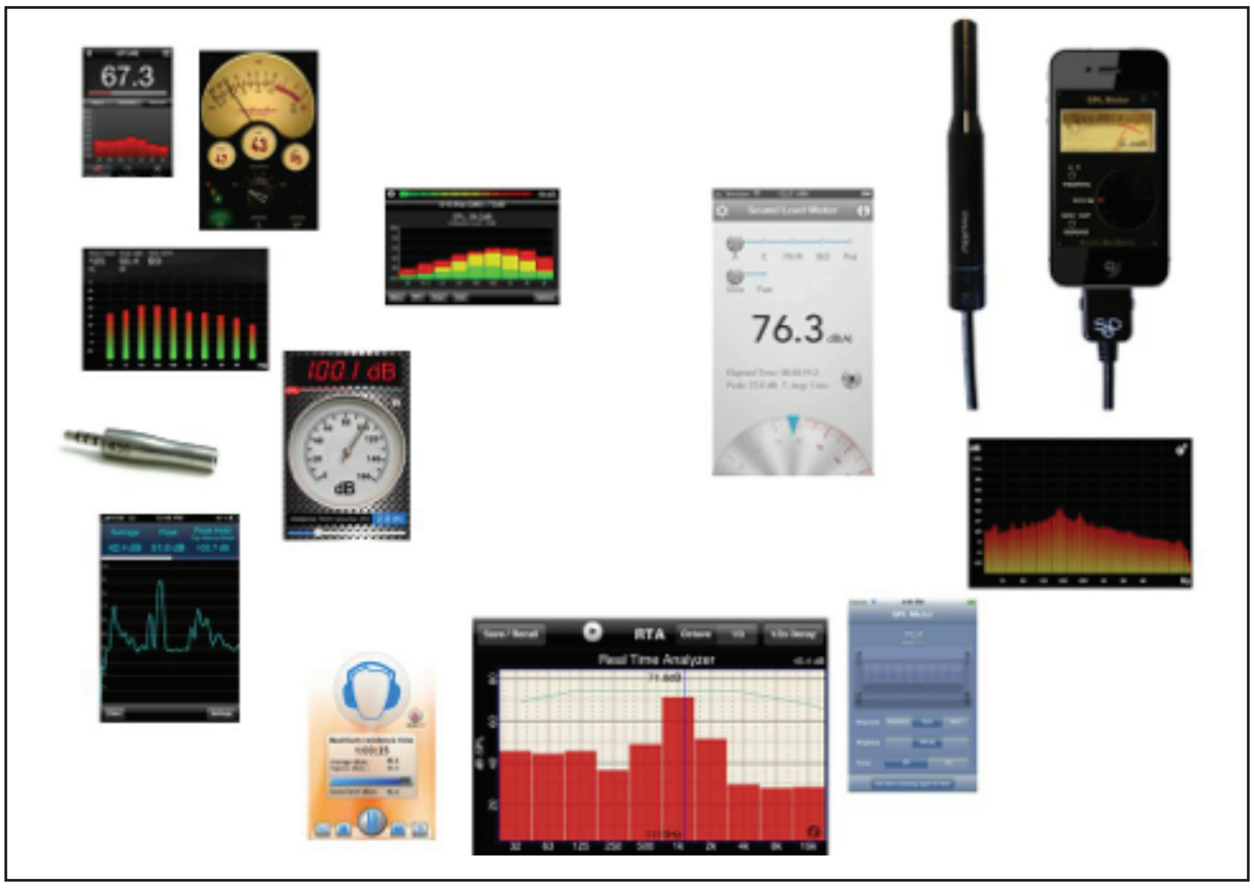


Figure 7

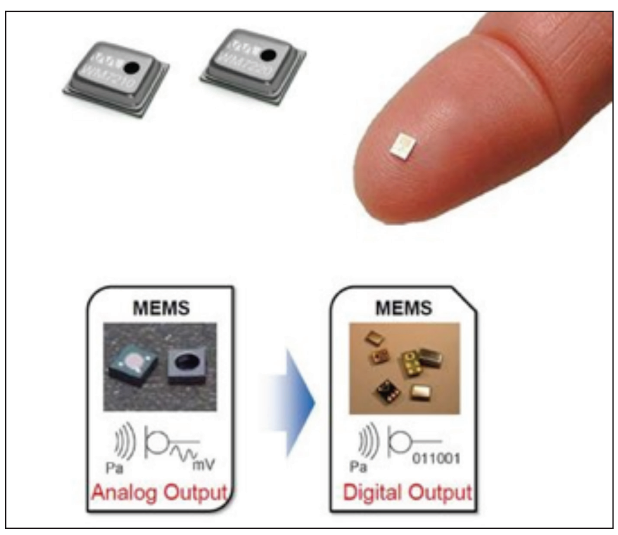
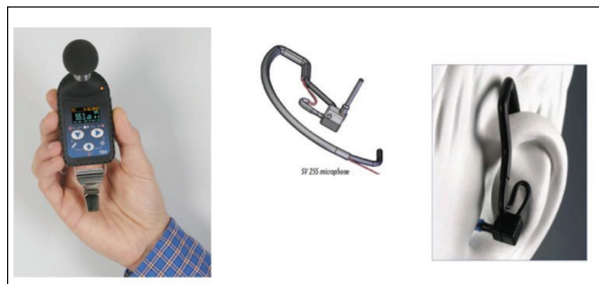


Figure 5

Can these be used for *measuring* sound? The answer to that lies in those standards that govern sound level meter performance, and right now, MEMS microphone performance falls short of those requirements. There is already a place for them as noise dosimeters **(Figure 6)** now employ MEMS techniques, as well as specialised techniques such as MIRE for in-ear measurements.

Consumer Sound Level Meters?

Now that everything can be done with an A/D converter and a DSP, we are seeing the rise of the App. Using the life support system of the smartphone (which already has MEMS microphones and DSP to burn), software applications are appearing which can turn a phone into a sound level meter **(Figure 7)**. Specialised extension microphones are also available to improve the acoustics and performance. Some even claim to meet sound level meter standards. Ironically, a few of these even have 'retro' analogue displays – a real full-circle!



Noise dosemeter MIRE (Measurements In Real Ear)

Figure 6

As with PC-based sound level meters 20 years ago, we should still be sure that standards are met so where do these apps fit in? The spectrum analyser apps are very good at finding

the frequency of an audible tone, but measuring the level is often only achieved accurately over a limited dynamic range. Also bear in mind that the electromagnetic environment inside a mobile phone is particularly hostile to low level noise measurements.

It's unlikely that Apple, Google or RIM will ever move into the sound level meter market – it's just too small and specialised. Also, producing a new model or operating system every year will obsolete our phone-based instrument too quickly, but the traditional manufacturers can feed off the crumbs left behind – a Class 1 sound level meter with a MEMS microphone is not far off.

Summary

This article has, I hope, given an overview of sound level meter development over the last few decades, highlighting the move from analogue to digital, and consequent increase in value for money.

Where will it end? In my view, sound measurements will become even more integrated to the internet – maybe one day our digital MEMS microphone will connect directly to the Cloud, and our noise report will be written before we even get back to the office, along with weather, photos, GPS, maps. Plug your microphone into your Google glasses?

About the Author

John Shelton has been in the sound & vibration instrumentation business for over 30 years, and recently celebrated 20 years of AcSoft Ltd, pioneers of PC-based instrumentation. A member of the IOA, he is a founder member and current Chairman of the IOA Measurement & Instrumentation Group and sits on several committees relating to sound & vibration measurement.