THE ROLE OF THE PERSONAL COMPUTER IN ACOUSTICS

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1. INTRODUCTION

With the advent of ever more powerful personal computers there is a tendency to believe that they are the panacea for all acoustical measurement tasks. Despite their increasing power and speed the newer machines may still not be able to achieve the required accuracy and meet all of the relevant standards that apply according to current best practise.

Much of the work carried out in acoustics can be split into three distinct areas, namely; primary, secondary and tertiary processing. The collection of raw data in the form of the instantaneous sound pressure level (Lp) or the time averaged sound pressure level (Leq) are examples of primary processing. These data are averaged over longer periods of time to calculate and produce the statistical percentile levels (Ln) which are examples of secondary processing. Finally the resultant long term measurement sets are often required to be presented in a standard format for inclusion into a report and this is characterised by the requirement for tertiary processing.

Many applications for noise measurement require the collection of data under severe environmental conditions and the personal computer may not be best suited to this particular task. In these circumstances the more familiar Precision Sound Level Meter will be the preferred instrument for the collection of on-site raw data and the personal computer will be the favoured solution to provide the manipulative tasks for further analysis.

2. OVERVIEW OF THE REQUIREMENTS

The measurement of acoustic signals for typical industrial or environmental noise applications usually requires that data is acquired at the relevant position over a relevant period of time. This may be anywhere from the workshop of a noisy factory to the outskirts of a town for background noise assessments during the night.

Both of these examples indicate that to adequately characterise a complex noise climate a relatively long measurement may need to be made under potentially severe external conditions. In the early days of noise measurements this might have been accomplished using a sound level meter and a high quality analogue tape recorder. However, there were serious limitations for the acoustics practitioner if it was deemed necessary to measure for any time longer than approximately an hour.

The most significant limitation in this case was probably the total running time of a reel of recording tape such that the frequency response would still be of an acceptably wide range. In such a situation the sound level meter was only used as a front end power supply for the microphone and preamplifier in order to provide a calibrated signal on the tape recorder. Once this had been obtained it was then necessary to spend probably two or three times longer than the actual recording time to obtain the required answers from the tape recording by playing back into more sophisticated instruments in a laboratory.

Developments of the "humble" sound level meter continued at a tremendous rate through the 1970's and 1980's such that it became possible to dispense with the need for an analogue tape recorder since many of the required noise parameters could be directly obtained at the actual measurement site in real time. This has obvious advantages in terms of time saving and overall accuracy since it was now not necessary to use extra pieces of equipment to produce the required answer.

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During this period the International Standards for sound level meters were updated and republished [1] & [2] outlining the specifications for both simple instantaneous and time-averaged sound pressure level measurements. Contained within these specifications are the necessary requirements for an individual instrument or system in order for it to produce acceptable answers demanded by the busy acoustic professional.

In most situations the users do not need to concern themselves with the method of operation of their instrumentation, indeed it can be argued that it should not really be necessary for the user to worry unduly about whether they will be likely to obtain the "right" answer at all. This is because the instruments will usually carry some mark or identification which confirms to the user that it will thoroughly meet all the tasks that are expected of it.

This should be true for any good quality sound level meter produced by a reputable manufacturer since they will have gone to great lengths to design their product to satisfy these exact requirements. But this is not quite true of a personal computer since this is, by design, a general purpose piece of equipment that has primarily been designed to operate in an office environment usually on a desk top not in the middle of a field at half past three in the morning on a cold wet day.

Let us consider some of the specific demands placed upon a piece of electronic equipment when used for a typical noise measurement.

3. PRIMARY PROCESSING

As sophisticated as personal computers are it can be recognised immediately that they will not be able to measure noise on their own. It will still be necessary to have a suitable transducer, in this case a microphone capsule, to provide an analogue input signal. However, due to the extremely high impedance of the typical precision measurement microphone it is also necessary to follow the transducer with a suitable preamplifier and impedance converter.

These are active devices and will therefore need a suitable power supply of the right voltage and power rating. Many precision sound level meters use air condenser microphones and these require that a stabilised DC polarising voltage, typically 200 volts, is available to energise the microphone. It is not always easy nor indeed possible to guarantee that these basic requirements will be readily available from the circuitry of a typical computer.

Furthermore, it is usually necessary to obtain the frequency weighted time history of the noise therefore the 'A' or possibly 'C' frequency responses must be available within the computer in order to obtain meaningful data. For more detailed assessment of the noise climate it is quite often necessary to perform constant percentage frequency analysis in the form of either whole octave or one third octave band analysis.

A particular characteristic of general noise recording is that signals possess a very wide dynamic span. It is not unusual to need to measure levels in the range of 20-30 dB at one moment and then to be able to handle sudden transients that may exceed 100 dB. This places a demand on the computer to be able to provide some sort of amplification or attenuation of the raw input signal from the microphone and hence more circuitry before any real measurements can be made.

It can be readily deduced from the foregoing arguments that a considerable amount of additional circuitry is required to pre-condition the raw analogue microphone signal before we can even consider using the processing power of the personal computer. Even assuming that this circuitry is provided in the form of a "plug-in" card covering all of these requirements it may not be possible to fit this card into the limited amount of space available in the smaller portable computers.

Let us assume that a suitable card could be produced that will provide all of the above requirements and that it will physically fit into the computer of our choice. What will there be in the way of markings to assure the user that this is a piece of equipment suitable for the tasks that are needed to be carried out?

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It is very unlikely that the manufacturer of the computer will be able to categorically state that their original product was tested and found to comply with the relevant acoustic standards since it was not originally designed with this purpose in mind. Similarly, the manufacturer of the "plug-in" card may not have the necessary resources to guarantee complete compliance with all the subtle nuances of the specifications. This is not likely to instill the end user with much confidence that the measurements will be acceptable if questioned in any form of litigation.

Let us examine some of the practical realities of using a notionally compliant personal computer for noise analysis purposes.

Computers are fundamentally digital devices that are able to perform certain calculations at an incredible rate when compared to other possible methods. In the case of an audio signal with a bandwidth of up to 20 kHz it will be necessary to sample the continuous analogue microphone signal at at least twice this frequency in order to accurately transform the data. Moreover, because of potential aliasing problems a slightly faster rate will normally be used in practise, say 50 kHz.

The computer will need to use 2 eight bit bytes to describe each sample that is digitised in order to be able to resolve the sound level to 0.1 dB. Therefore, at the suggested sampling rate described above there will be;

50,000 x 2 = 100,000 bytes of data every second.

In other words a typical hard disk of 100 Mbytes capacity in a personal computer would be full after only 1000 seconds or about 16 minutes.

It can be seen that it is not practical to consider digitising the input signal from the raw ac microphone output because of the severe limitations that this would impose upon the storage capability. A more practical approach is to consider digitising the more slowly varying dc signal that is used to drive the display in the sound level meter. This has the disadvantage that it no longer possible to go back to exactly the original analogue input but it will still contain enough information for most purposes depending upon our new sampling rate as described below.

The source of this slower varying analogue signal is immediately after the RMS detector and therefore this part of the sound level meter will now also need to be included on the card in the computer. Providing that the output of the detector is sampled at approximately ten times the selected time constant then an adequate representation can be obtained. For the S (SLOW) time constant, or time weighting, this means a sampling rate of 10 Hz. For the F (FAST) time weighting this equates to a sampling rate of at least 80 Hz, more probably 100Hz.

Thus the 100 Mbyte capacity of the hard disk from above will now be able to store 100,000,000 / 200 ie. 500,000 seconds of data sampled with the F time weighting. This is approximately 5 3/4 days of recording. The other two specified time weightings I (IMPULSE) and P (PEAK) will restrict the system to even shorter recording times.

It can be readily appreciated that the use of a personal computer for the capture of primary data will soon generate enormous amounts of data which must then be analysed for the required end results. The foregoing arguments together with the practical considerations of portability, battery consumption, size, weight, ability to withstand the harsh environments that a sound level meter is used in tend to indicate that there are certain practical limitations in its use on-site.

4. SECONDARY PROCESSING

Where the personal computer can really benefit the busy acoustician is in its ability to communicate with the sound level meter once a measurement has finished. This method requires that the sound level meter is fitted with a digital interface that is able to translate its data output into the required computer format. It may be necessary at this stage to convert the low power voltages used in modern instrument designs to the levels required by the computer.

The transfer method will usually be according to the RS-232C protocol to provide a serial stream of answers which have been captured on site. In instruments not fitted with the benefits of a memory it may be necessary to use an intermediate storage medium such as a data logger or to directly connect the computer to the sound level meter and transfer the dataset as it is being recorded.

If the sound level meter has been used to store the more fundamental noise parameters then the computer may be put to good use to perform the more tedious but relatively simple tasks as suggested below. Many longer term noise assessments are currently based on the manipulation of short period time averaged sound levels. For example in measurements of construction site noise [3] the 12 hour Leq from 7 am to 7 pm is often required.

Although modern instruments should be able to measure for this 12 hour period considerable useful information would be lost if only the actual overall 12 Leq was obtained. It is far more illuminating to measure and store the hourly Leq's and then to use the computer to calculate the accumulative 12 hour Leq from the 12 individual results. In this manner it is possible to inspect the original data to find the approximate time of any high noise levels that may have caused an agreed overall limit to be exceeded.

Calculation of traffic noise for the purposes of entitlement to secondary glazing is based upon the assessment of the average value of the 10 percentile noise level from 6.00 am through to 12.00 pm. The 18 hourly L10 values are measured and arithmetically averaged to achieve the final overall result. This is again a task which can best be accomplished by transfering the period data to the computer which will then calculate the final result. Adopting this approach may also help to minimize any potential for human error to creep in.

5. TERTIARY PROCESSING

Once the original raw data has been collected at the place and time that is relevant and the dataset transferred to the computer for further simplification it is logical to use the power of the computer to incorporate the results into the final format. This will usually involve importing the data in the form of tables or listings into a word processing package for the ultimate output. If the original raw data such as short period Leq or Ln results have been retained it will often be beneficial to add these as graphs or charts. Many current word processing packages are also able to provide the user with drawing facilities so that sketch plans of the measurement site can be included to aid the end user of the report.

6. CONCLUSIONS

The modern sound level meter is a complex and sophisticated piece of equipment. It is designed to perform according to its stated tolerances over a very wide and arduous range of circumstances. Although it is possible for a personal computer to act as an instrument it can be readily appreciated that the primary processing tasks discussed above are likely to be fulfilled in a more rigorous manner by the Precision Sound Level Meter.

However, where the personal computer can be used to great advantage is in the secondary and tertiary stages of data processing. This will enable the professional acoustician to confidently obtain the necessary raw data on site in a small convenient device safe in the knowledge that the measurement has been carried out in a systematic and fully compliant fashion.

REFERENCES

[1] British Standards Institution, "Specification for Sound Level Meters" BS 5969:1981, IEC 651:1979.

[2] British Standards Institution, "Specification for Integrating-Averaging Sound Level Meters" BS 6698:1986, IEC 804:1985.

[3] British Standards Institution, "Noise control on construction and open sites" BS 5228:1984.