INTER-ACTIVE NOISE MONITORING USING THE GSM TELEPHONE NETWORK

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1. INTRODUCTION

Remote interrogation of noise monitoring terminals is not new but has been becoming more a more attractive option recently due to the falling costs of the hardware needed and the escalating costs of personnel and their associated travel expenses. Couple this with the rising aspirations of the public at large that actions will be taken, in short order, to deal with those environmental problems that cause them problems the need to have information on line looks an attractive proposition. We just have to bend the current technology to make it fit the needs of the busy Environmental Control Engineer. To date computer terminal equipment has been needed at both the central and remote end of the data link; this paper addresses the steps necessary to access remote data using the GSM technology that drives the conventional mobile phone that is now in every day use.

2. CURRENT TECHNOLOGY

Unattended environmental noise monitors differ from conventional sound level meters only in as much that they have to be both weather and vandal proof and provide their results electronically to a remote location. Rasmussen[1], who has configured both all weather and weather-protected configurations for measurement microphones, has successfully dealt with the problems of protecting the microphone from the elements. His solution is to design a purpose built system rather than try to adapt standard indoor capsules by adding extra components that make use of the tolerances, intended for normal use, to cover their insertion losses. The added problem of the reference angle moving 90^0 away from the source as the microphone has to be rotated from the horizontal to vertical to allow the rain deflector to operate correctly is also addressed by his designs. Protection of the electronics has been tackled in a number of ways depending upon the severity of the climate and the risk of vandalism at the monitoring location. Norsonic[2] have engineered a range of instrument enclosures for both permanent and semi permanent noise monitoring installations to suit even the severity of the Norwegian winter. The permanent stations are provided with double skinned cabinets to ensure that the internal temperature is controlled by convection in high summer and heating systems, both natural and forced, to deal with the problems of winter. Access is via security locks and tilting masts enable acoustic calibration on the microphone to be carried out single-handed. In areas of high risk of damage by vandals fencing around the terminal is recommended. These solutions are for locations where mains power and telecommunication links are available; although there is no reason why solar power and radio links cannot be used for these permanent locations where access to the required services are not available.

Where the distance between the remote noise monitor and the central station is less that about 1.5k metres and there are no problems of way leave it is possible to use conventional line drivers as the communication medium giving the added advantage of zero call charges. For longer distances then it is necessary to rely upon the public telephone network; the ever increasing importance of data transmission to the telephone companies is being manifested by the continual reduction in call charges and increases in data transfer rates that may be achieved. These improvements are beginning to change the concepts of data reduction that has been a key part of noise monitoring systems for many years. The sound level meters themselves perform data reduction by converting the audio signal, acquired at sample rates of up to 48k Hz, into single number metrics over set periods of time such as $L_{eq,1hour}$ along with supporting L_n values. These values are also often supported by separate measurements of acoustically significant events such as aircraft over flights etc; as these events are key in determining the value of the main measurement parameter having them correctly identified is very important. It is this compressed data that is sent over the remote data link.

A variant of the permanent noise monitor is the semi-permanent system; here the design compromises have to be tilted in favour of making the outstation portable and self contained to allow it to be moved to different locations as required. . It is also possible to harness the features of the GPS network to have the system automatically log is location and add the information to the data stream as a set of geographical coordinates. Semi permanent systems have to be battery powered and engineered to be self-contained. Modern technology allows the power consumption of instruments to be significantly reduced such that a single 10 Ah battery, normal motorcycle size, will power the instrument and its accessories for over a week so that is not a major area of concern. Communications has been revolutionised by the mobile phone system that now covers most parts of the country. The addition of an industrial cell phone modem within the instrument housing will allow data to be transferred from any location at any time; devices such as the Siemens M20T provide dual channel transfer of audio and data over the GSM mobile telephone network.

3. DEVELOPING THE LIVE AUDIO LINK

The ability to listen in to the actual noise at the outstation is a valuable aid in correctly identifying the source, as the human ear is still more powerful than the most advanced frequency analysis system. The problems associated with doing this come from the limited dynamic range of the telephone network and the poorly defined gain that is applied in the telephone network. It is not uncommon for modern noise monitoring systems to have a dynamic range of more than 100 dB as this allows them to accurately measure an aircraft over flight at 120 dB(A) yet still be able to determine background noise levels around 25 dB(A). In these systems a typical environmental noise source with a level around 60 dB can be some 60 dB down from the maximum and approaching the limit of dynamic range of the telephone network rendering it inaudible over the telephone link. The answer is to provide a system of gain, either manual or automatic to lift the level so it can be heard correctly over the phone link. The provision of gain in the remote monitoring station and the way in which it is set is shown in figure 1. Applying gain to the audio signal gives the problem of then not knowing what the actual level was, it may sound loud but that may be due to the gain applied either at the terminal or in the telephone network. To overcome these problems a system has been developed that uses a speech synthesiser driven by the sound level meter's measurement channel to generate an "announcement" of the measured level. This is then mixed with the audio signal from the terminal and coupled to the analogue connection to the terminal modem. The result is that is possible to listen to the noise climate by simply dialling the noise monitoring terminal phone number, this will bring on line an amplified analogue of the noise climate at the outstation that will be "calibrated" every 10 seconds by a voice message.

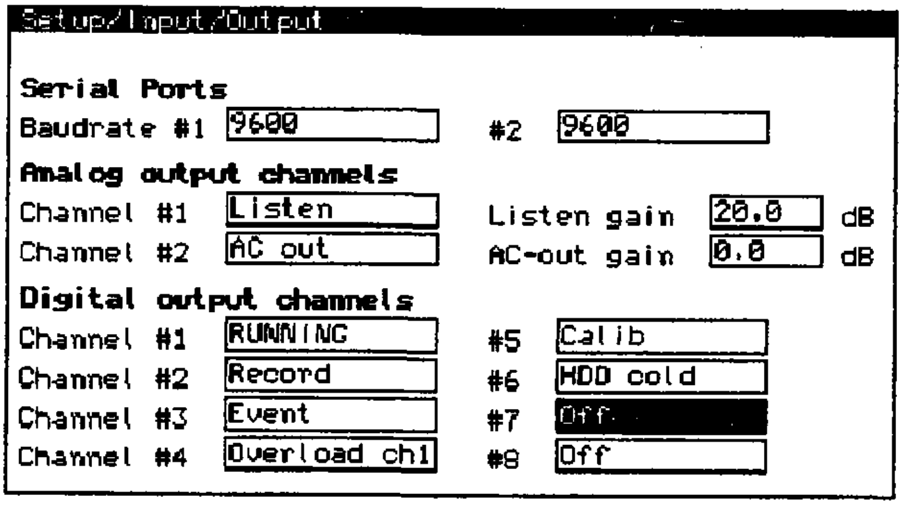

Figure 1. Setting the Listen gain in the Norsonic Nor-121 Environmental Analyser

The system is fully automatic and it is possible to have it in almost any language; to date the voice has been synthesised in English, German, Norwegian, Czech and Slovakian. It is now possible to call the outstation at any time to check the current noise level with out the need for a computer, with a mobile phone it is not even necessary to be in the office! The system has brought an unexpected benefit to GSM phone users in as much that it overcomes the automatic disconnection features when a line goes inactive; when typical voice patterns lapse into "pseudo white noise" many networks use this to indicate that the conversation has finished or connection has been lost and the call is then automatically terminated. The presence of the voice from the synthesizer on the line will keep the call open in those situations such as in between aircraft over flights where the call saver function would have been activated.

4. DEVELOPMENT OF THE MOBILE DATA LINK

Computers can only talk to Computers, this fact has to date limited the ability to access data from a remote terminal; even with the development of small lap-top computers it was still not convenient to access remote noise data. One of the facilities offered by the current generation of mobile phones that could be useful in overcoming these problems is the short message service, SMS. This feature allows the transmission of short text messages from one mobile phone to another; many phones allow pre-composed messages to be stored in the handset and then transmitted as required to overcome the problems associated with typing on a telephone keypad. This SMS service offers a digital data link from a conventional mobile phone without the need for a modem and special computer programs. It has been used to still further improve the ability of the Environmental Control Engineer to interrogate the noise monitoring terminals. The sound level meters in the remote terminals have been engineered to include an SMS transponder that will respond to certain SMS message text; when the message text is decoded by the GSM modem and passed to the sound level meter it will respond by formatting the data requested and initiating the "reply" function in the GSM modem with a text stream comprising the requested data. Send the terminal a SMS message that simply says "MEM" and a few seconds latter a reply will be sent to the originating phone number giving the current available memory in kilobytes,

Instruction	Command	Parameter	Comment
Get available SMS commands	MENU	None	Returns "Menu: BATT MEM G R1 R2 R3 R4 R5 P LAEQ LCEQ LAFSPL LCFSPL LAFMAX LCFMAX STATE TIME HDDTEMP TEMP WIND PKWIND DIR RAIN WETGND".
Get battery status	BATT	None	Returns battery voltage or %.
Get memory status	MEM	None	Returns free memory in kilobytes of current storage device.
Get data from global report	G	LAEQ ... LCFMAX	Returns measured data from global report Available functions: LAEQ, LCEQ, LAFSPL, LCFSPL, LAFMAX and LCFMAX
Get data from periodic report x	R1 ... R5	LAEQ ... LCFMAX	Returns measured data from a periodic report
Get data from profile report	P	LAEQ ... LCFMAX	Returns measured data from profile report
Get elapsed measurement time	TIME	None	Format "Time: HH:MM:SS"
Get current HDD temperature	HDDTEMP	None	Temperature in °C
Get temperature	TEMP	None	Temperature in °C, from Weather Station
Get average wind speed	WIND	None	Returns average wind speed in m/s, from Weather Station.
Get peak wind speed	PKWIND	None	Returns peak wind speed in m/s, from Weather Station.
Get wind direction	DIR	None	Returns wind direction in the range 0° ... 360°, from Weather Station.
Get amount of rain	RAIN	None	Rain in mm since last reset of rain detector. The rain detector will be reset once every day.
Get wet ground status	WETGND	None	If ground is wet 1, else 0.

Use <space> to separate between commands and between command and parameter

Figure 2. SMS Commands for Norsonic Nor-121 Environmental Noise Analyser

send "BATT" and the reply will be the remaining battery capacity in percent. In addition to these housekeeping functions data can be obtained by sending commands that specify the time period and the parameters required. Send "MENU" and the reply will give the configuration of the remote terminal; from this the required SMS text messages to access the data may be determined. As there are limitations on the SMS message service the data requests are formatted into a number of short commands that will bring specific data sets; after all the system is intended to give speedy access to data in the field and not to provide comprehensive data for detailed analysis. A full list of typical commands is shown in figure 2. In this case sending the SMS message "R4 LAEQ" will return the measured L_{Aeq} value from the measurement report designated as number 4 in the instruments set up; this is usually the last 5 minutes data.

If a weather station has been installed via the sound level meter in the remote terminal then an additional set of commands is available to allow meteorological information to be retrieved over the SMS system. Interrogating the terminal via the SMS system will not corrupt the data in any way or interrupt it normal measurement and data collection functions.

Further development of the basic system to make it proactive would be to engineer a system that would initiate an SMS message, to a predefined number, when a pre-programmed acoustic event occurs. There is already a comprehensive system within the noise-monitoring terminal for the specification of acoustic events; these may be defined as threshold exceedence with time delays or even a dynamic system based, for example, on the preceding 5 minute L_{90} value in the 63 Hz octave band. So once the event has been defined a message will be transmitted as soon as the conditions have been met thereby allowing the Environmental Control Engineer to take the necessary community relations or corrective actions in good time. Modern sound level analysers are also capable of streaming actual noise data to a hard disk to make a standard computer *.wav file for latter recall; this allows retrospective listening to events in the same way as the real time mode. The control of the Environmental Noise Analyser via the SMS message system also offers the prospect of calling these audio records back to the GSM voice link to allow them to be reviewed retrospectively via the calibrated voice link described earlier in this paper.

4. CONCLUSIONS

The need for dedicated computers and software for remote access to the data held by noise monitoring terminals is no longer necessary. Audio data may be transmitted over a standard telephone voice line that is calibrated by a voice synthesiser driven by the sound level meters measurement channel. Making use of the SMS message system provided by the GSM mobile telephone network it is possible to access digital information. Both current and historical data may be obtained, and by a system of key words in the message pre-formatted data reports are possible covering both acoustic and weather data. Further development of the system would allow proactive actions to be taken whereby the sound level analyser would initiate a call to a predefined number when an acoustic event occurs.

[1] Weather protection of measurement microphones. Gunnar Rasmussen. Proceedings of Inter-noise 95. International Institute of Noise Control Engineering.
[2] Environmental noise monitoring solutions www.Norsonic.com March 2001