A LOOK AT THROAT SINGING

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1. INTRODUCTION

Throat singing is a peculiar vocal art that allows a singer to sing simultaneously with two, three and even four voices. It is also known as overtone singing, biphonal singing and harmonic singing.

The source of speech or singing are the vocal cords (or vocal folds) located in the trachea. They are set to vibration by periodically closing the passage of the air exhaled from the lungs. The frequency of this interruption, which gives the fundamental frequency of the sound, can be as low as 70 Hz. Its energy is relatively low, reason for not being perceived in normal speech or singing. Another characteristic of the sound so generated is that it is far from being sinusoidal and contains many harmonics.

Once generated, the sound waves travel through the vocal tract. There, the different harmonics contained in the original sound, are amplified by the resonant activity of the various cavities found along the tract. Those harmonics, known as formants, are the result of the transformation of the buzz emitted by the vocal folds into something much closer to speech or singing. The transformation of the sound does not end with the action of the vocal tract. Once the sound waves exit the tract, there is the external filtering, due to the radiation characteristic of the head as well as to the impedance mismatch between the acoustical fields inside and outside the mouth cavity.

In normal speech and singing the false vocal cords (false folds) are not used at all for generating sound waves. In throat singing, unlike in normal singing, the vocal cords are still the main sound generator. However, there are many other flexible structures inside the tract that can be set to vibration. They are: the false cords (paired tissues located directly above the true cords), the arytenoids cartilages (which sit in the rear of the throat and help control phonation), the aryepiglottic folds (tissues between the arytenoids and the epiglottis) and the epiglottic root (the lower part of the epiglottis). All of them can be set into vibration, resulting in the various types of throat singing.

There are three basic styles of throat singing:

a) Khoomei
b) Kargyraa, and
c) Sygyt

Each style is also divided into various sub-styles.

Throat singing is practiced by nomadic tribes of South Siberia, located basically in the tiny republic of Tuva (that now is a part of the Russian Federation), Western Mongolia, Tibet, Sardinia and Bahrain. Tibetian monks throat sing as expression of faith. However, in Tuva, people sing about their everyday life and special times in their past. Some popular topics are horses, the countryside and their families.

The York University Overtone Throat Singing choir, called "Sound Shatter" is probably the only throat singing institution in Canada. Besides replicating Tuvian Throat singing, they sing "normal" vocal music. Also, they try to develop extended vocal range and unique and idiosyncratic timbers.

Many studies have dealt with the subject of throat singing (see references). In our case, one of the authors (MK) is a throat singer. That gave us the opportunity to perform a limited study, using "real" samples of this particular style of singing.

Our original intention was to perform a multidisciplinary study, involving acoustical as well as laryngoscope analysis. The acoustical part of the study was performed at the IBBME and reported here, while Dr Annie Ramos Pizarro was to perform the laryngoscopy at the St Michael's Hospital, Toronto. Unfortunately, because of Dr Ramos moving to the USA, the laryngoscope aspect of the study was initiated, but not finished at this time.

2. MATERIAL

Samples of singing were taken from:

a) Two "normal" singing male subjects, D (age 31) and A (age 69). Each sample consisted of a steady sound of some 15 or so seconds duration, keeping constant the loudness and the pitch. Those samples were used for comparison with samples from throat singing. Only one sample was collected from each of the "normal singing" subjects.

b) One male subject, (age 30) performing three types of throat singing: Kargyraa - Mountain, Kargyraa - Steppe ("Mountain" and "Steppe" in this paper) and Sygyt. Three samples were taken from each type of

singing, to examine variations among the same type of singing. For this purpose, the singer was instructed to try to repeat each sample exactly in the same way.

Subjects were requested to emit the sound signal and to keep it steady for some 15 seconds. This duration is necessary for the processing of the signal by the analyzer.

3. INSTRUMENTATION

Signals were collected using an ATF - Artificial Test Fixture (1), one of whose auditory canals was equipped with a Zwislocki type DB100 coupler and a B&K type 4134 microphone thus simulating the acoustic impedance of a human ear. The singers and the ATF were located in a double (two rooms), double walled audiometric room type IAC No 109277. The output from the ATF was analyzed in 1/3 octaves bands, using a B&K Dual Channel Real Time Frequency Analyzer Type 2144.

The measuring system was not calibrated, since we were only interested in the relative values of the sound levels at the different frequencies. Because all measurements were conducted within a period of a couple of hours, it was assumed that the characteristics of the system did not change.. Therefore, differences between samples are accepted as intrinsic and not due to variations in the components of the measuring system.

4. MEASUREMENT RESULTS AND OBSERVATIONS

4.1 Two "normal "singing males.

Figure 1 shows the spectra of the two "normal" singing subjects A and D. With the exception of the interval 100 - 200 Hz, it can be seen that the general shape of both spectra is similar. It follows a pattern typical for male voices, with most of the energy contained in the interval 400 – 2000 Hz.

It should be noted that the first important harmonic of the singer A has a frequency of 125Hz, while that of singer D is one octave higher, at 250 Hz. The fundamental frequency of both singers, that is close to 63 Hz is not noticeable in any of the two spectra.

4.2 Throat singing

Figure 2, shows the spectra obtained from the three samples of the Mountain style. It can be observed that the peaks and valleys in the three spectra are located at the same frequencies. Some large differences between sound levels at the same frequency can also be observed. This can be expected, since no specific precautions were taken to keep the loudness and the pitch constant during the session.

The spectra in Figure 2 show three distinct peaks at 63.5, 125 and 200 Hz. The first corresponds to the fundamental frequency, resulting from the vibration of the vocal cords. As mentioned above, in general it does not contain much energy and is not detected in normal singing. While the second peak is a harmonic of the first, the third peak is not, suggesting that it is due to independent vibrations of structures other than the vocal cords.

The spectra of the Mountain samples show a pattern that resembles the most to the "normal" singing pattern as opposed to the other throat singing types. This is better illustrated by comparing the spectra in Figure 3A and Figure 3B where the averages of the two male samples and this of the three Mountain samples are shown. It can be seen that in both averages most of the energy is concentrated in the 500 – 1600 Hz region. However, on the "normal" singing side, there are

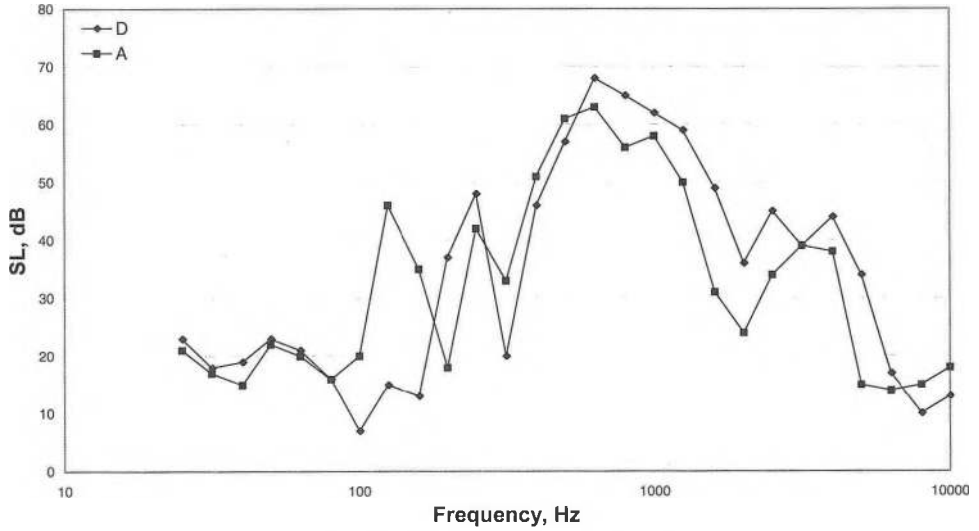

Figure 1. Samples 'A' and 'D'.

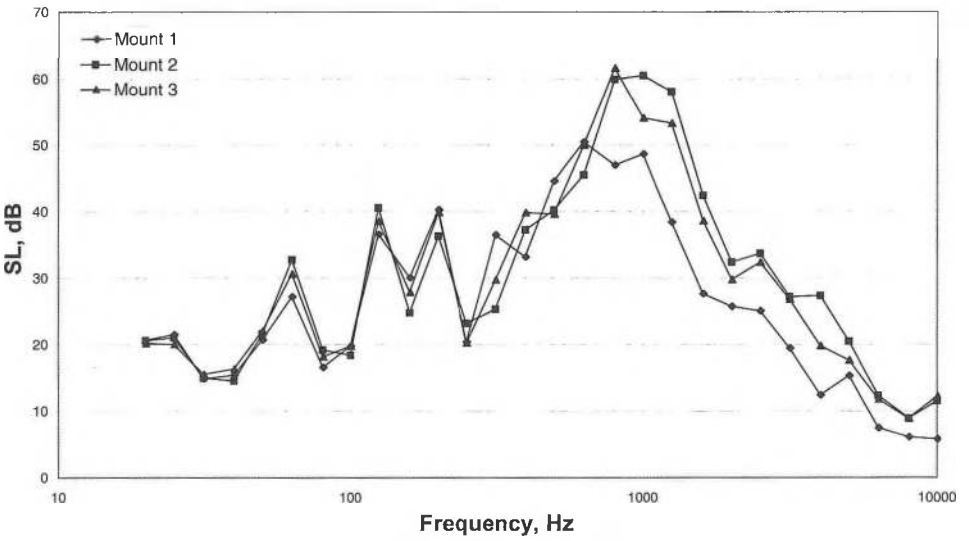

Figure 2. Three MOUNTAIN Samples.

only two peaks that are harmonically related: at 125 and 250 Hz.

The three Steppe style samples are shown in Figure 4. Again, it can be observed that individual peaks are located at the same frequencies, thus allowing for the use of their average, shown in Figure 5. The pattern here is quite distinct: there are peaks at 63.5, 125, 200, 315 and 400 (those two not clearly distinguished), and 1250 Hz. It is interesting to observe that, except for the 63.5 Hz peak, the other four peaks have similar sound levels. There is no significant energy contribution at frequencies higher than 2 kHz.

The three Sygyt type samples, shown in Figure 6, exhibit similar locations of their peaks and valleys. Figure 7 shows the average of the three samples. Here the pecks are located at 250, 500 and 2000 Hz, with most of the energy located between 200 and 3150 Hz, with no significant contributions outside those frequencies. It is interesting to observe a valley at 100 Hz, showing a resonant absorption.

All nine (9) throat-singing samples were obtained from the same subject. Therefore, any conclusion should be taken with caution.

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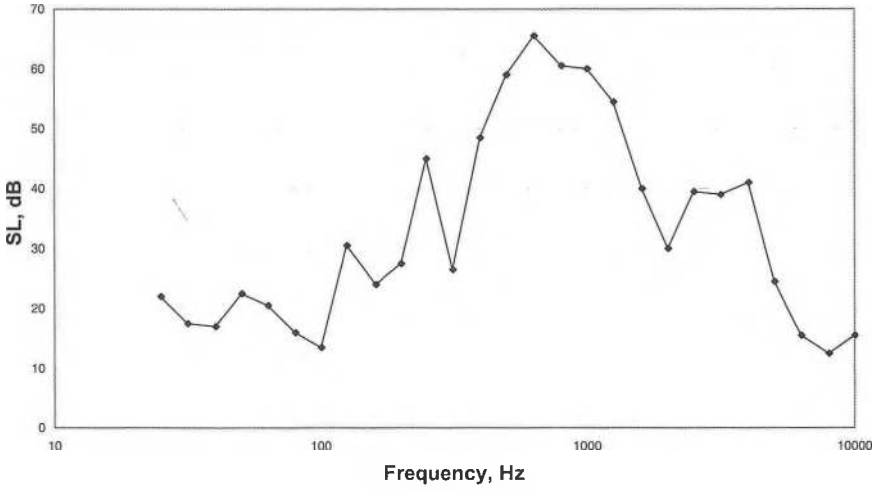


Figure 3A. Average of MALE Samples.

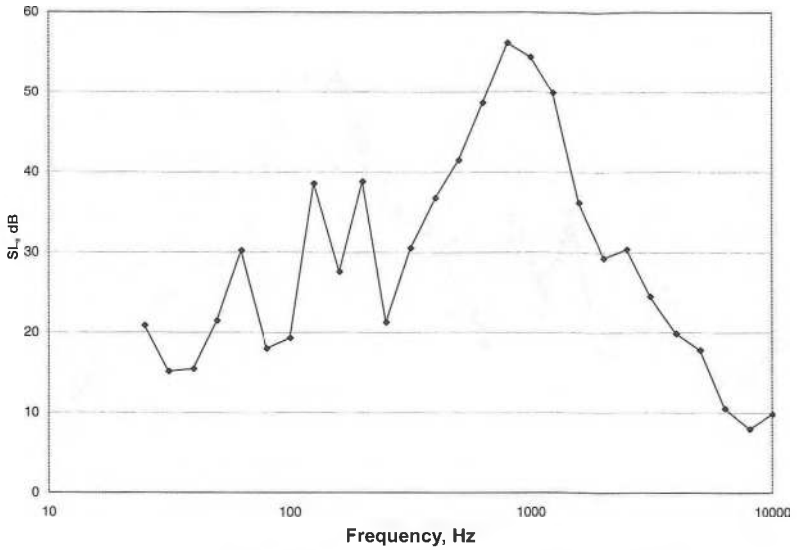


Figure 3B. Average of MOUNTAIN Samples.

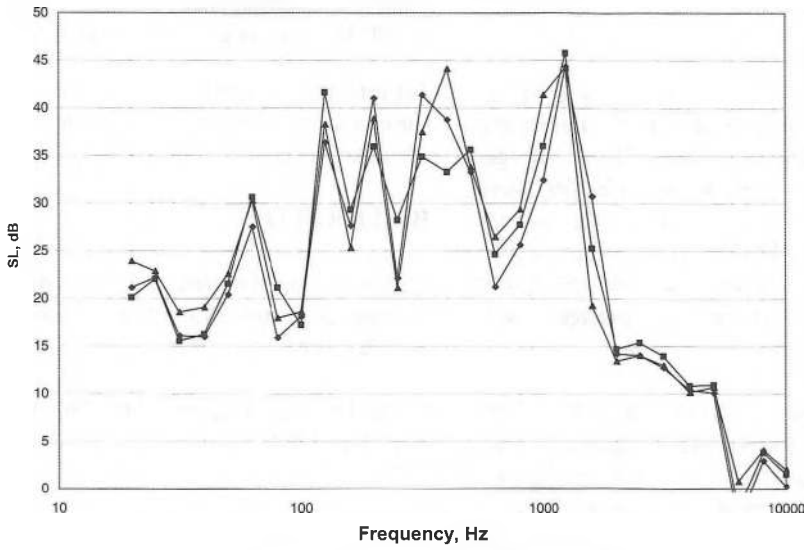
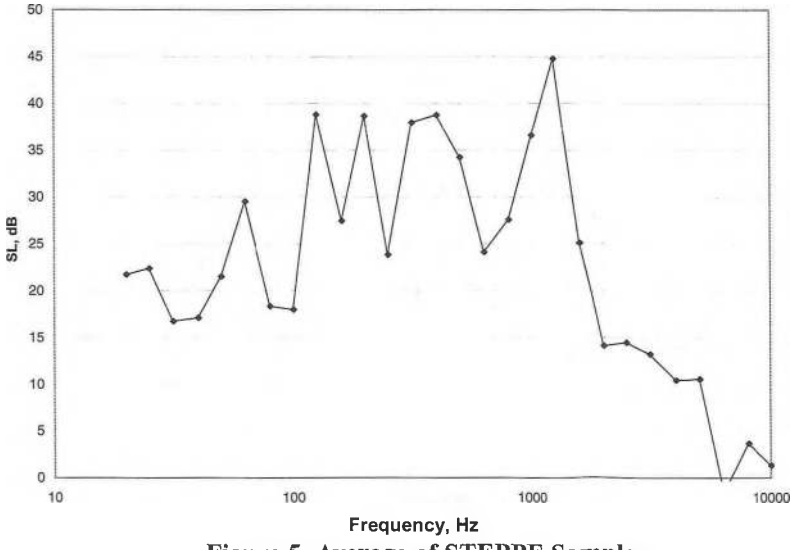


Figure 4. Three STEPPE Samples.



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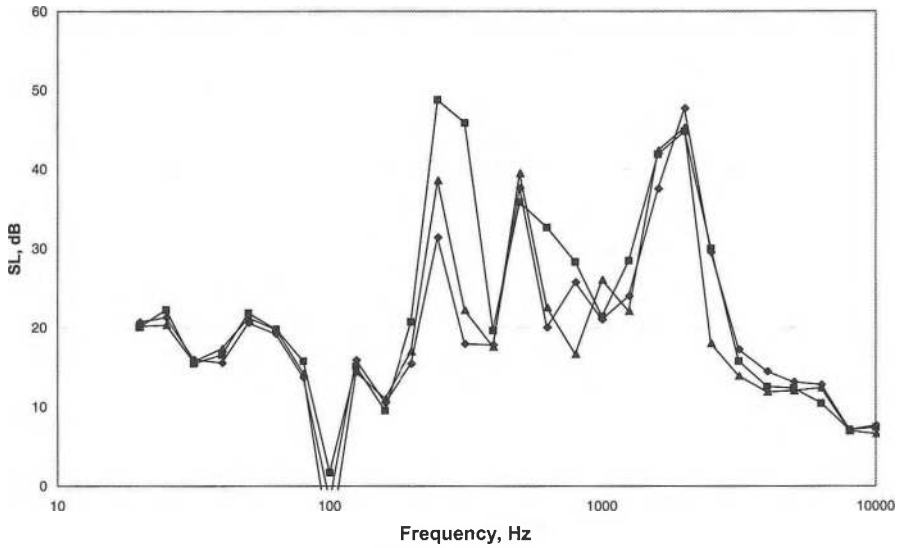

Figure 6. Three SYGYT Samples.

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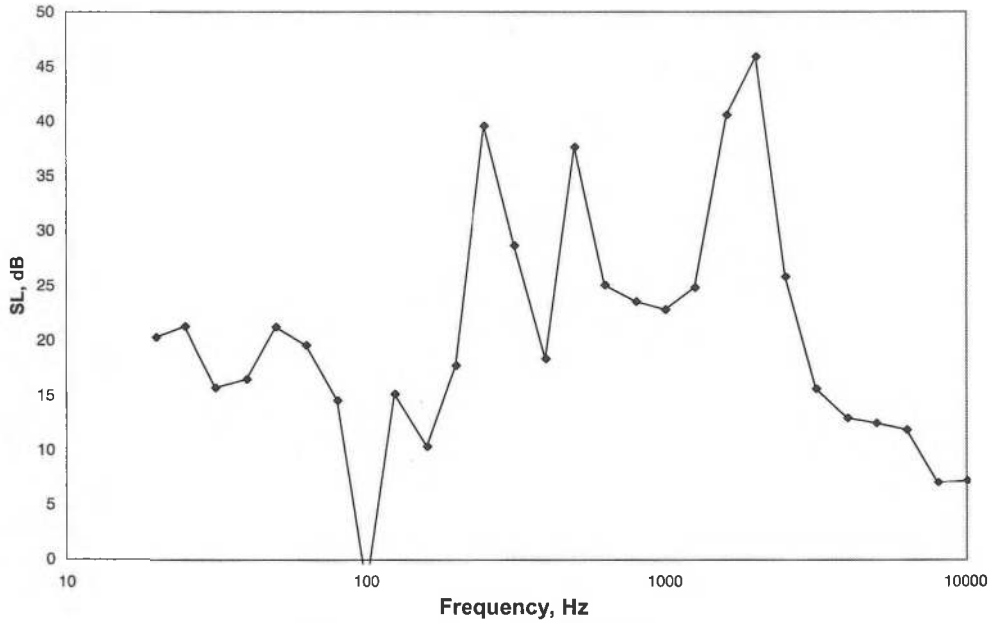

Figure 7. Average of SYGYT Samples.

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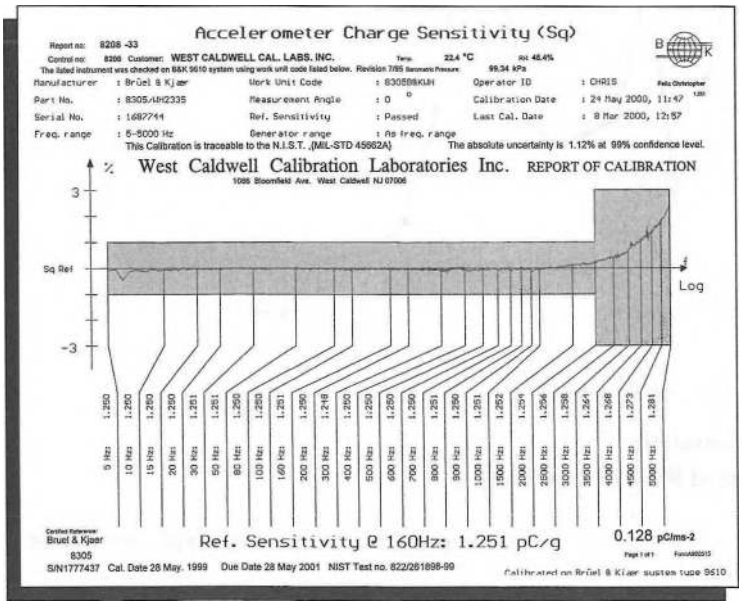
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Control no: 8208 Customer: WEST CALDWELL CAL. LABS. INC. Temp. 22.4 °C Rel. 46.4%
The listed instrument was checked on B&K 9610 system using work unit code listed below. Revision 7/95 Barometric Pressure: 99.34 kPa

Manufacturer	: Brüel & Kjær	Work Unit Code	: 8305SHKLH	Operator ID	: CHRIS
Part No.	: 8305/SH2335	Measurement Angle	: 0 °	Calibration Date	: 24 May 2000, 11:47
Serial No.	: 1687744	Ref. Sensitivity	: Passed	Last Cal. Date	: 8 Mar 2000, 12:57
Freq. range	: 5-8000 Hz	Generator range	: As freq. range		

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5 Hz	10 Hz	15 Hz	20 Hz	30 Hz	50 Hz	80 Hz	100 Hz	160 Hz	200 Hz	300 Hz	400 Hz	500 Hz	600 Hz	700 Hz	800 Hz	900 Hz	1000 Hz	1500 Hz	2000 Hz	2500 Hz	3000 Hz	3500 Hz	4000 Hz	4500 Hz	5000 Hz
1.250	1.250	1.250	1.250	1.251	1.250	1.250	1.250	1.251	1.250	1.248	1.250	1.250	1.250	1.250	1.251	1.250	1.251	1.252	1.254	1.256	1.258	1.264	1.268	1.273	1.281

Certified Reference: Brüel & Kjær 8305 S/N1777437 Cal. Date 28 May. 1999 Due Date 28 May 2001 NIST Test no. 822/261898-99

Ref. Sensitivity @ 160Hz: 1.251 pC/g 0.128 pC/ms-2

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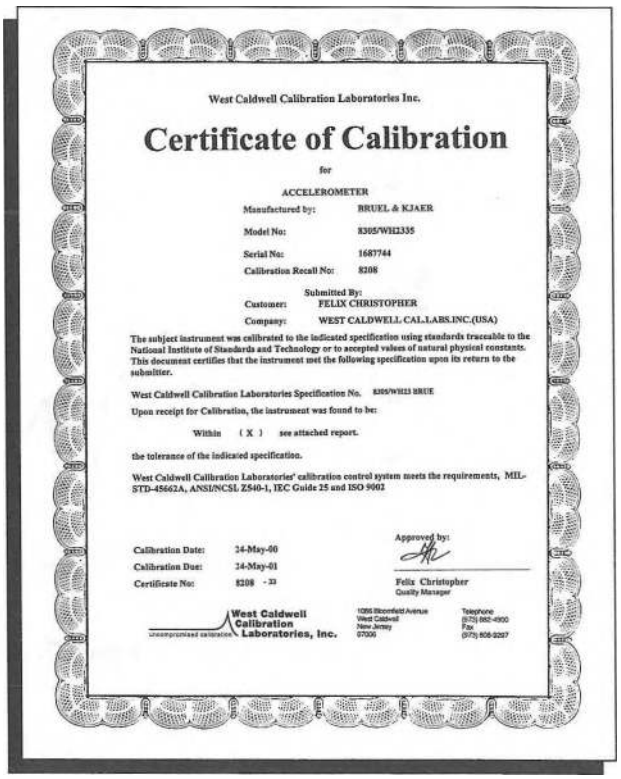
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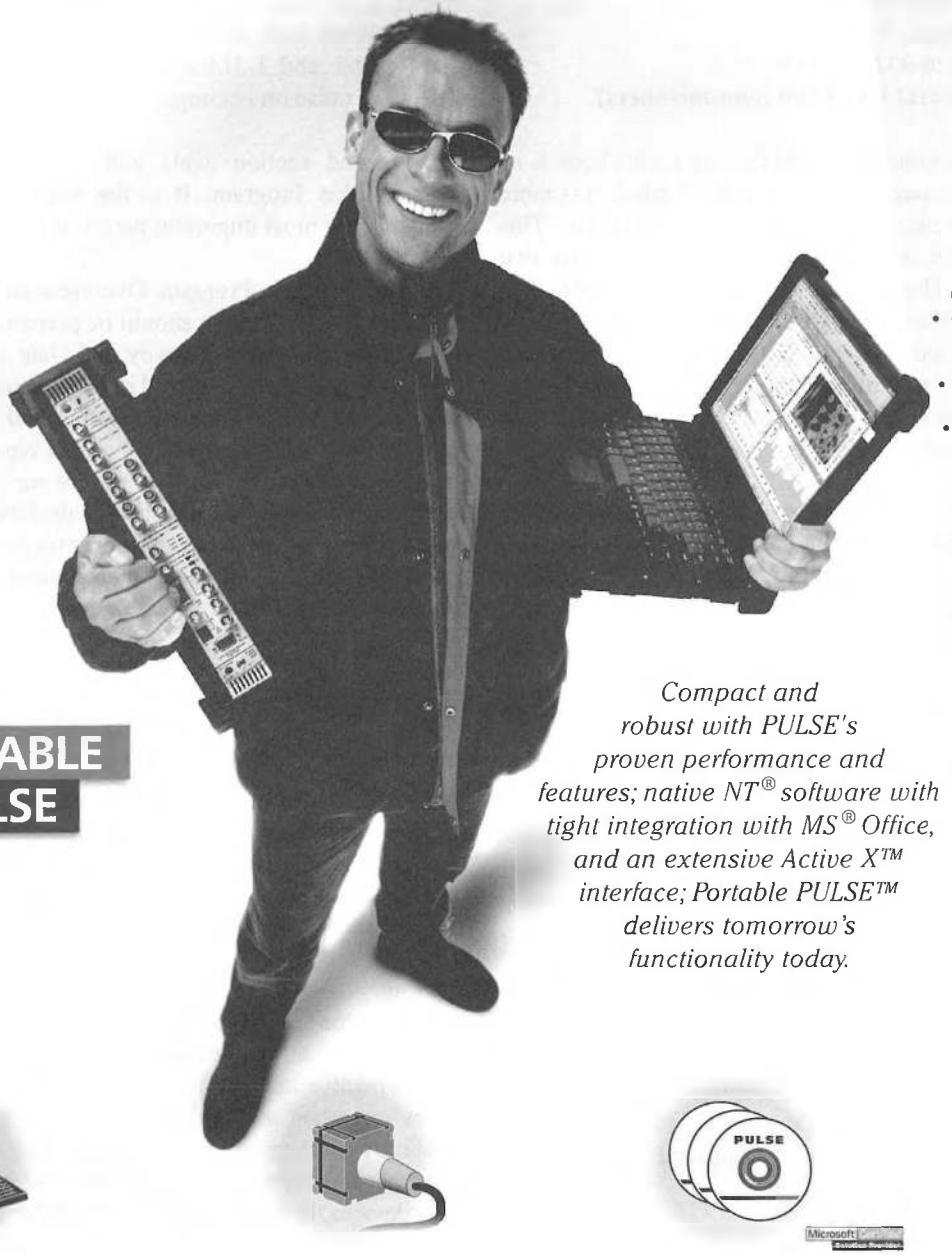

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