The 51-channel spectrum analyzer - a status report

Garpengahl, G. and Liljencrants, J. and Rengman, U.

journal: STL-QPSR
volume: 3
number: 3
year: 1962
pages: 001-005

http://www.speech.kth.se/qpsr
I. SPEECH ANALYSIS

A. THE 51-CHANNEL SPECTRUM ANALYZER - A STATUS REPORT

Introduction

This instrument is designed as a research tool for spectrum analysis in the frequency range 0 - 10 kc/s by means of a bank of 51 bandpass filters. It is primarily intended for real time speech analysis but it will accommodate any signal that can be transposed to the pertinent frequency band. In order to insure a wide field of applications it has been designed with a very high degree of versatility.

Some of its major applications are:

(I) Sequential sampling of amplitude/frequency spectral sections with various degrees of frequency and time resolutions.

(II) "Visible speech" display of connected speech for monitoring purposes.

(III) Large scale statistical processing of speech signals.

(IV) Vocoder analyzer simulation.

(V) Spectrum analysis for speech recognition schemes.

The output is presented on a digital basis. It is stored as such or/and as analog representations of consecutive spectrum sections (Mingograf ink jet recorder). A transfer of digital data to punched paper tape will allow digital computer processing.

In those parts of the analyzer where the signal is treated on an analog basis (filters etc.) the instrumentation is mostly equipped with vacuum tubes. All digital circuits are fully transistorized.

The following is a brief description of the instrument according to the block diagram of Fig. I-1.

x) A tentative description has been published earlier, see ref. (1).
Fig. 1-1. Block diagram of 51 channel analyzer.
Letters correspond to headings in the text.
Signal path

a. Signal source. The input signal is taken from one of the tracks of a standard audio magnetic tape recorder. The other track is occupied by a time marking signal. The signal may alternatively be taken from a tape scanner or some other type of analog memory device facilitating repeated playback.

b. Input amplifier. The audio signal is amplified and low pass filtered with 10 kc/s cutoff frequency. Various HF emphasis filters are available.

c. Heterodyne system. The signal is frequency transposed with a carrier in the range 24 to 34 kc/s. The part of the lower side-band that is falling below 24 kc/s is re-transposed to the audio region with a fixed 25 kc/s carrier. With the aid of the variable carrier any part of the input spectrum may be shifted in frequency to match the analysis filter bank.

d. Analysis filters. Each filter consists of three cascaded RLC resonant circuits interconnected with cathode followers. Losses in the inductance elements are compensated by means of activation. The resonance frequencies and bandwidths of the circuits are chosen to give minimum overshoot characteristics to the combination. See further ref. (2). The filters may easily be switched to operate with one of the resonant circuits. The filter bank consists of two groups of filters:

Group A comprises 10 filters with mid-frequencies equally spaced in the frequency interval 0 to 0.9 kc/s. Their bandwidths are variable from 62 to 500 c/s. Group A is not used together with the heterodyne system.

Group B contains the remaining 41 filters. The first filter is centered at 1 kc/s and the others range upwards. Frequency spacings and bandwidths are variable according to the following table:

<table>
<thead>
<tr>
<th>SPACING</th>
<th>f 12.5</th>
<th>25</th>
<th>50</th>
<th>100</th>
<th>200 c/s</th>
<th>80 tm</th>
</tr>
</thead>
<tbody>
<tr>
<td>RANGE Wb</td>
<td>0.5</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>8 kc/s</td>
<td></td>
</tr>
<tr>
<td>B = BANDWIDTH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31 c/s</td>
<td>1</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>62</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>125</td>
<td>3</td>
<td>5</td>
<td>7</td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>250</td>
<td>6</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td>11</td>
</tr>
<tr>
<td>500</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>300 tm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
e. **Full wave rectifiers.** The rectifiers are linear within 0.5 dB over a 60 dB range.

f. **Smoothing filters.** The rectified voltage is integrated with third order RC-active low pass filter with minimum overshoot characteristics (See further ref.\(^2\)). The integration time constants are variable from 1.6 to 400 ms corresponding to cutoff frequencies from 250 to 1 c/s. Special precautions are taken to preserve stability and dynamic range.

g. **Analog/digital converters.** Each channel is equipped with one converter. The conversion is carried out on a logarithmic basis (comparison of the input with an exponentially decreasing reference combined with time measurement). All channels are sampled simultaneously and the conversion is completed in less than 1 ms. The quasi-stationary voltage from the smoothing filters is thus quantized in 128 levels in 0.5 dB steps. The seven bit result is stored within the converter and is presented to a common digital output line on order from the switch control system. The converter is called SaDiStoLog, a name derived from the functions of the unit. It is described in detail in ref.\(^3\).

h. **Visual displays.** The digitized signal is converted to a time measure and displayed as a frequency/level diagram on a 19" television CRT. If the audio signal is taken from a tape scanner a "visible speech" display will be available on a separate unit.

i. **Digital data storage.** The digital output is generally recorded on a multitrack magnetic tape recorder. If the recording is played back at reduced speed the data may be transferred to punched paper tape for further use with computers.

k. **Analog data storage.** The slowed-down data from the digital recorder is passed through a digital/analog converter and displayed as consecutive spectrum sections with the aid of an ink jet direct-writing recorder (Mingograf) for visual inspection.

l. **Binary/decimal converter.** The seven-bit output of the analyzer is converted to the corresponding decimal notation ranging from 00.0 to -63.5 dB. The result is displayed with nixie tubes for convenience during adjustment and checking. A binary coded decimal output will be available for computer work.
Control system

m. **Time marking code generator.** The marking signal consists of a 400 c/s reference superimposed on time marking position modulated pulse pairs occurring every 12.5 ms. There are five different kinds of pulse pairs. Those of the highest order occur at 200 ms intervals. These intervals are successively divided in two by pulse pairs of lower orders.

n. **Time marking decoder.** The decoder will respond to marking pulse pairs of a predetermined order or higher. Start orders are then issued to the sampling devices in the analysis channels (via the sampling unit). The sampling intervals will thus be adjustable in octave steps between 12.5 and 200 ms.

o. **Sampling program unit.** This unit will incorporate a preset counter e.g. for taking samples at one specified time instant. There will also be a delay network for interpolation between the time markings on the input magnetic tape.

If the input signal is taken from a tape scanner it will be possible to use the same technique as in our present analyzer Rasslan (5)(4). In that case one sample is first taken covering a small frequency range from zero and upwards. Next time the same signal arrives from the tape scanner the heterodyne system has automatically been provided with a new carrier frequency so that the second sample will cover a frequency range adjacent to that of the first. This procedure is repeated till the whole input frequency range is covered. Using this method it will be possible to take a spectrum containing some 800 narrow band measurements (this is an extreme example which hardly is of practical interest).

p. **Heterodyne control unit.** This unit will contain a stepwise frequency variable oscillator giving the first carrier to the heterodyne. The frequency is controlled by the sampling program unit or manually.

q. **Converter control.** The analog/digital converters are governed by this unit. When the conversion is ready the scanning switch is actuated.
r. **Switch control unit** comprises a clock pulse generator and a set of ring counters.

The data in the Sadistologs are sequentially switched to the analyzer output. The primary switching gates are incorporated in the Sadistolog units. These are interconnected in groups of ten which in turn are sequenced by secondary gates.

The scanning speed is variable in five steps corresponding to the five possible sampling intervals.

**Status:**

Under development: h, n.
Prototypes: k, l, m, q, r, power supplies.
In production: d, e, f, g.

**References**


G. Garpendahl, J. Liljencrants, U. Rengman