A Music Bar for active listeners: An example of Virtual Electronic Lutherie for a history 50 years long

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ABSTRACT

This paper presents initial results of an ongoing project devoted to the analysis and virtualization of the analog electronic devices of the "Studio di Fonologia Musicale", one of the European centres of reference for the production of electroacoustic music in the 1950's and 1960's. After a brief summary of the history of the Studio, the paper discusses a particularly representative musical work produced at the Studio, namely the analogue tape work *Scambi* composed in 1957 by Henri Pousseur. Finally, the paper presents initial results on the analysis and simulation of the electronic lutherie used by Pousser in this composition, and the ongoing work finalized at developing an installation that re-creates such electronic lutherie.

1. INTRODUCTION

"I can easily imagine that in the not too distant future the possibility of doing such work will become generally available. [...] The whole material could be made available to amateurs in some kind of 'music bar'. The joy of turning the volume control – maybe in company – or even of a little spatial distribution, [...] would help to give the now active listener the experience of how the course of an event can be influenced and raised to the form of a vital, creative freedom." [1, p. 54]

A classical musical composition (a Beethoven symphony, a Mozart sonata, or Stravinsky Rite of Spring) posits an assemblage of sound units that the composer arranged in a closed, well-defined manner before presenting it to the listener. He converted his idea into conventional symbols, obliging (more or less) the (eventual) performer to reproduce the format devised by the composer himself. On the contrary, a number of music (or, more generally, multimedia) works are linked by a common feature: the considerable autonomy left to the individual performer in the way he chooses to play the work [2]. Thus he is not merely free

to interpret the composer's instructions following his own discretion (as happens in traditional music), but he must impose his judgment on the form of the piece, as when he decides in what order to group the sounds: an act of "improvised creation" [3]. An example is Klavierstück XI by Karlheinz Stockhausen, where the composer gives to the performer a single sheet of music with note groupings, and the performer has to choose among groupings and mount the sequence of musical units in the order he chooses, thus altering the combinative structure of the piece. One second example is the Third Sonata for piano by Pierre Boulez, where the first section (Antiphonie, Formant 1) is composed of ten different pieces on ten corresponding sheets of music which can be arranged in different sequences (although with some constraints in possible permutations).

A particularly representative example of musical open work is *Scambi*, an analogue tape work created in 1957 by the Belgian composer Henri Pousseur (1929 – 2009) at the *Studio di Fonologia Musicale* in Milan. An analysis of this work is provided in [4]: by means of a specific process, termed "dynamic filtering" and realized through a custom device (the *Selezionatore di ampiezza*, or "amplitude selector", designed by Alfredo Lietti [5], the engineer of the studio), the composer extracted complex time structures from noise, and further processed them eventually producing 32 sequences. These sequences can be arranged by anyone who had access to them and who wished to realize the work, according to certain rules regarding their order and possible overlapping. Together with the composer and the performer, the third main actor, in this sense is the listener.

Today's technology increasingly enables novel forms of interaction between users and multimedia content. To a certain extent this is also true for music content: high quality music can be enjoyed on low-cost and even mobile devices, can be selected by users depending on their taste and mood, and so on. However, to date music listening remains a passive and non-interactive experience: there is the need for novel approaches that can encourage an active music listening experience, in which the listener can interact with the music content, modify it, and ultimately recreate it. In this perspective the listener will become a prosumer. (as predicted in the 1980's by futurologist Alvin Toffler, who coined this portmanteau by contracting the word "producer" with "consumer").

The aim of this paper is to report on initial results of an

ongoing project devoted to the analysis and virtualization of the analog electronic devices of the Studio di Fonologia Musicale. The final goal is to develop an installation consisting of a SW-HW system that re-creates the electronic lutherie of the Studio, allowing users to interact with such lutherie. In particular, the production setup originally employed to compose *Scambi* is considered as a relevant case study. Achieving the goal of the project implies *(i)* analyzing the original devices through both project schemes and direct inspection; *(ii)* validating the analysis through simulations with *ad-hoc* tools (particularly Spice – Simulation Program with Integrated Circuit Emphasis, a software especially designed to simulate analog electronic circuits [6]); *(iii)* developing physical models of the analog devices, which allow efficient simulation of their functioning (according to the *virtual analog* paradigm [7]); *(iv)* designing appropriate interfaces to interact with the virtual devices.

The remainder of the paper is organized as follows. Section 2 briefly summarizes the history of the Studio di Fonologia. Section 3 discusses in some detail the form and the realization of Scambi. Finally, Sec. 4 presents initial results on the analysis and simulation of the electronic lutherie used by Pousser for the composition of *Scambi*.

2. THE *STUDIO DI FONOLOGIA MUSICALE*

The Studio di Fonologia Musicale [8] was founded in 1955 at the Milan offices of the Italian Radio-Television (RAI), under the initiative of the italian composers Luciano Berio and Bruno Maderna. In a few years, the Studio became one of the European centres of reference for the production of electroacoustic music, by deploying cutting-edge devices for the generation and processing of sound. Often these devices were especially designed and crafted by Alfredo Lietti: oscillators, noise generators, filters, dynamic and frequency modulators. These were unique pieces, created with great care to meet the needs of the composers who attended the Studio.

In 1967 the Studio underwent a partial renovation. As a consequence, much of the older equipment was dismantled and has been lost. However, thanks to records kept in archives (photographs, schemas, drawings and articles) it is possible, in many cases, to know the characteristics and the functionality of most equipments that no longer exist. The Studio was closed in 1983 and the devices were disassembled and transported to Turin, where they remained packed in storage until 2003, when they were returned in the RAI headquarters in Milan.

The electronic lutherie of the Studio di Fonologia Musicale has recently been transferred to the Milan Museum of musical instruments: this inestimable technological and cultural heritage is now accessible to the general public in a permanent museum exhibition. However the electronic devices and sound generators are not currently functioning, they are exhibited as mute instruments and visitors can only listen to recordings of musical compositions that made use of these devices. As a consequence, it is not possible to fully appreciate the variety of timbral and expressive possibilities of these instruments, which could be experienced only by directly interacting with them. The museum is thus seeking for solutions that allow visitor to experience such an interaction, possibly by a virtual recreation of the devices.

The cultural value of the electronic lutherie of the Milan Studio is testified by the efforts devoted jointly by RAI and the Milan Museum of musical instruments, in order to set-up the current exhibit. In fact the Milan Studio, together with its counterparts in Paris and Cologne, was one of the topical places of early electronic music, and during the 1950's and 1960's was able to attract composers of international stature. Henry Pousseur was among them.

3. *SCAMBI*

We propose now the analysis of an interesting case study: Pousseur's electronic work *Scambi*, following [4]. Writing about his work in 1959, Pousseur ended by envisaging the day when technology would allow listeners to make their own realizations of the work (either following his connecting rules or not) and to give the, now active, listener the experience of a temporal event open to his intervention and which could therefore be elevated in type, as vital, creative freedom [1]. The active listener becomes, in effect, a composer; reception and interpretation are expressed as (musical) production.

In our work, Pousseur's invitation to creatively interpret and re-compose his work is extended to other types of appropriation that were not only permitted but welcomed by the composer [1] (a position that associates him with popular-music culture in which such freedom is assumed). In our case study, we have collected the original 32 audio sequences realized by Pousseur, thanks to the *Scambi Project*, Lansdown Centre for Electronic Arts, School of Arts, Middlesex University, UK (http://www.scambi.mdx.ac.uk).

3.1 Form and realization of *Scambi*

Pousseur focused on material which could be easily produced through real-time processes (he only had six weeks for the realization of the work). The work is based on a set of sequences, connected to each other based on a set of rules. Sequences differed from each other in terms of four musical parameters: the statistical tempo (from slow to fast), the relative pitch (from low to high), the "homogeneity" of the sound pattern (from dry to long reverb), and the "continuity" (from long silence gaps to continuous sound) (see Fig. 1).

Sequences were constructed as follows. The composer extracted irregular impulse patterns from input signals made of white noise band-passed at different center frequencies. These signals were processed through "dynamic filtering" with the *Selezionatore di ampiezza*. The device acted approximately as a noise gate (see Sec. 4), therefore depending on the settings the output signals extended from a isolated impulses to complex swarms of pseudo-random impulses. Through mixing and montage of the tapes obtained from this process, he constructed four basic sequences, in which only one parameter among tempo and pitch is

Family	Sequence	Pitch	Speed	Hom.	Cont.	Dur.
1	1-2	0/1	1/1	1/0	0/0	42"
2	3-4	0/1	1/1	0/1	1/1	42"
3	5-6	1/0	1/1	0/0	0/1	42"
4	7-8	1/0	1/1	1/1	1/0	42"
5	9-10	1/1	1/0	1/0	1/0	30"
6	11-12	1/1	1/0	0/1	0/1	30"
7	13-14	1/1	0/1	0/0	0/0	30"
8	15-16	1/1	0/1	1/1	1/1	30"
9	17-18	0/0	0/1	1/0	0/1	30"
10	19-20	0/0	0/1	0/1	1/0	30"
11	21-22	0/0	1/0	0/0	1/1	30"
12	23-24	0/0	1/0	1/1	0/0	30"
13	25-26	1/0	0/0	1/0	1/1	42"
14	27-28	1/0	0/0	0/1	0/0	42"
15	29-30	0/1	0/0	0/0	1/0	42"
16	31-32	0/1	0/0	1/1	0/1	42"

Figure 1. Pousseur, *Scambi*, table with transformation processes; characteristic per sequence [4].

pitch	1	1110	111000	1000	0
speed	1	1101	100110	0100	0
homogeneity	1	1011	010101	0010	0
continuity	1	0111	001011	0001	0
selected sequences	*	*	* **	* **	

Figure 2. Pousseur, *Scambi*, table with transformation processes; all possibilities of characteristics and Pousseur's choice [4].

changing. These sequences could be played backwards, could be reverberated, and finally processed again with dynamic filtering. Pousseur executed only a part of the possible combinations in each work process, obtaining 32 sequences (see Fig. 2).

3.2 A *Music Bar*

The so-obtained sequences could then be arranged by the composer, according to rules defining their order and overlapping. The identity of the work would be mantained even between markedly different arrangements, due to the homogeneity of the sound material which would always create the same general impression [1].

Pousseur writes in the booklet accompanying the compact disc: "Several sequences (which begin with a same character) can even be superposed and thus lead to a polyphony of divergent situations – until they come together again on a common point." [9]. An example of branching structure leading to poliphony is shown in Fig. 3: the performance starts with sequence 1 and ends with 23. The arrows indicate which sequences connect with each other. At one point there are four layers proceeding simultaneously.

The analysis outlined above allows to identify some characteristics of the open-form [2]: the interchange of sections within certain constraints, and the possibility of combin-
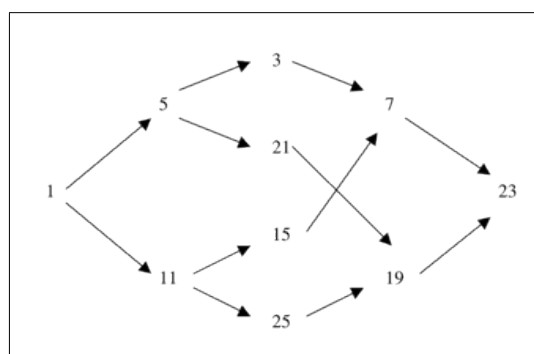

Figure 3. Example of branching structure.

ing sections. In particular Pousseur specified "connecting rules", according to which only certain sequences beginning with the same character could be rearranged. In fact several versions of *Scambi* exist. Two were realized by Pousseur himself, one by Marc Wilkinson [10], and two by Luciano Berio (who seems to have disregarded the connecting rules suggested by Pousseur).

Pousser's conception of open form can be summarized in the definition of 'music bar' given by the composer himself:

> "(...) I can easily imagine that in the not too distant future the possibility of doing such work will become generally available. All one needs at home is some splicing tape and leader tape and a simple tape recorder, or preferably two or three (and with several amateurs this should not be too difficult), which need not be perfectly synchronized, the small errors here leading to constantly new figures; else, the whole material could be made available to amateurs in some kind of 'music bar'. The joy of turning the volume control – maybe in company – or even of a little spatial distribution, requiring no expensive apparatus, would help to give the now active listener the experience of how the course of an event can be influenced and raised to the form of a vital, creative freedom." ([1, p. 54])

Therefore, as a consequence from his work on *Scambi*, Pousseur envisaged a new way of musical praxis in which the composer provides source materials which have to be further developed by each prosumer [4]. In this sense, Pousseur anticipates certain aspects of contemporary commercial developments where consumers today can, as an example, construct their own albums (often by downloading individual tracks) rather than passively accepting the products marketed by large corporations.
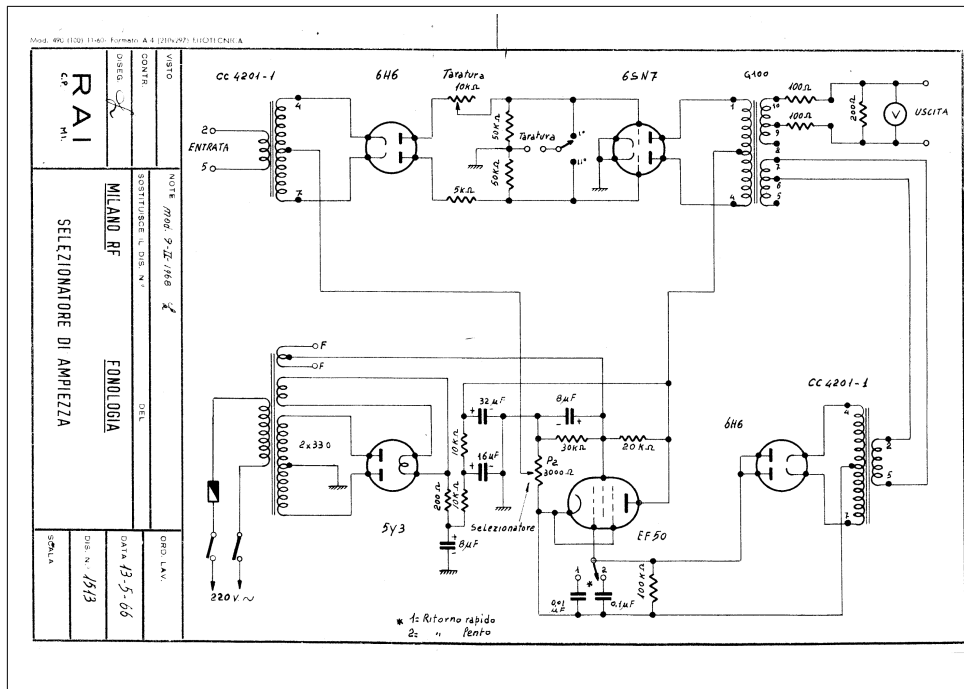
Figure 4. Original project scheme of the Selezionatore di Ampiezza.

4. VIRTUALIZATION OF THE ELECTRONIC LUTHERIE

This section presents the ongoing work finalized at realizing an installation at CSC (Centro of Sonologia Computazionale, University of Padova) consisting of a *music bar* [1, pag. 54], i.e. a SW-HW system that re-creates the electronic lutherie and the production setup that were originally used to compose *Scambi*: an equivalent of the concept of the *access copy* in the field of audio document preservation [11, 12]. The installation will be at disposal of visitors of CSC, who will have the possibility to directly interact with the virtual versions of the electronic instruments (sound generators, filtering devices, etc.) in the same way as electronic musicians did in the 1950's and 1960's, and will, therefore, be able to better understand the functioning and the possibilities of this kind of equipment. In particular, visitors will be able to compose their own versions of *Scambi* using the virtual equivalents of the original equipment and material employed by the composer, eventually realizing Pousseur's vision after more than 50 years.

4.1 Analysis and reverse engineering

Analysis of the analogue electronic devices is being conducted using the original projects of the devices, which are available at the Milan museum of musical instruments. Preliminary inspections indicate that the original project schemes are generally well documented in terms of characteristics of the basic components and of circuitry. In some

Figure 5. The front panel of the *Selezionatore di ampiezza* (photo courtesy of M. Novati [8]).

cases where the documentation is not detailed enough, it is necessary to inspect directly the original instruments through *ad-hoc* measurements on some components. Finally, in order to assess the accuracy of the analysis, the behavior of the devices has to be simulated using electronic engineering tools (particularly Spice [6]).

The circuit of the *Selezionatore di ampiezza* utilized by Pousseur in the composition of *Scambi* is depicted in Figure 4. The figure reproduces the RAI project schemes, which are slightly different from the ones originally presented by Lietti in [5].

The circuit has two operating modes, which depend on the activation status of the EF50 pentode.

1. When the pentode is off, no current flows through the potentiometer P2, so that the secondary of the input transformer CC4201 is connected to ground. In

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Figure 6. Rear view of the *Selezionatore di ampiezza* (photo courtesy of M. Novati [8]).

this case, the input signal, scaled by the input transformer, passes unchanged through the twin diode 6H6. The following bridge, composed by three resistances and the potentiometer P1, renders the signal symmetric: by means of the connectors and the switch positioned in the rear of the device (see Figure 6) it is possibe to tune the potentiometer P1 until the amplitudes in the upper and in the lower side of the bridge are equal. Finally, the dual triode 6SN7 amplifies the signal to drive the output stage.

2. When the pentode is on, the current flowing through the potentiometer P2 polarizes the secondary of the input transformer to the voltage V_p (depending on the position of the potentiometer). As a result, the current will flow through one of the diodes of the 6H6 tube only when the voltage of the input signal is, in absolute value, greater than the bias voltage V_p. If on the other hand the amplitude of the input voltage is less than V_p, the twin diode 6H6 is off and the output voltage will be zero. The knob at the bottom left of the front panel of the device (see Figure 5) lets the operator control the resistance value of P2 and the V_p threshold.

The activation status of the pentode EF50 depends by the feedback circuit: the output signal is drown from the connectors 6 and 7 of output transformer G100, it is rectified by the twin diode 6H6, it is filtered by the RC circuit and, finally, is applied to the suppression grid of the pentode EF50.

If a signal is present in the output stage, the twin diode 6H6 is on and the current flows through the RC circuit, biasing the suppression grid to a negative potential, in respect to the cathode. In this condition, the flow of current is inhibited and the pentode is off. Conversely, when there is no signal in the output stage, no current flows through the RC circuit and then the grid will be at the same potential of the cathode. Under these conditions, the pentode is on. The biasing of the pentode is provided by the power supply circuit, that rectified the alternate power supply through the tube 5Y3. The speed at which changes the pentode is

switched on and off depends on the speed at which the RC circuit responds to changes in the feedback signal, i.e. on the time constant of the circuit $\tau = RC$. The switch at the bottom right of the front panel (see Figure 5) lets the operator select between two time constants: $\tau_1 = 0.001s$ and $\tau_2 = 0.01s$.

4.2 Simulations

The circuit of the *Selezionatore di ampiezza* has been replicated in Spice. To this end, datasheets and libraries for all the circuit components have been found. Figure 7 shows a snapshot of the resulting Spice replica of the original circuit.

The final version of the paper will provide results from simulations, in particular the output of the circuit in response to

- sinusoidal signals with slowly varying amplitude and frequency;
- white noise with slowly varying amplitude.

5. CONCLUSION

The advent of digital technologies allowed to overcome many of the technical limitations of analog electroacustic devices. However the question is whether the electroacoustic community is exploiting these digital resources for new experiments in form. The authors strongly believe that now the composers are able to explore in exhaustive way the potential of open forms using new media and new Human Computer Interfaces But, in order not to constantly "re-invent the wheel", works such as *Scambi* must be regarded as being more important now than fifty years ago.

In this sense, the authors are developing the *Music Bar* for active listeners. starting from the original project and schemas of *Selezionatore di ampiezza*, the authors developed a system that allows the user-performer-composer to surf among the existing performances of *Scambi* and to create his own. Specifically, the installation will allow users to creatively interact with (i) virtual counterparts of the electronic devices of the Studio di Fonologia, and (ii) the production system of *Scambi* realized by Pousseur. The user-performer-composer will be able to surf among the existing performances of *Scambi* (e.g. by Luciano Berio and others), and to create his own, by selecting the original audio sequences used by Pousseur, and following (or not) the connecting rules proposed by the composer.

Future work will be devoted to the development of accurate and efficient virtual analog models of the original devices. Recently proposed techniques for the efficient simulation of nonlinear electric systems will be employed [13], and results from spice simulations of the circuits will be used to evaluate the accuracy of the virtual analog models.

A second key point for the effectiveness of the final installation is the design of the user interface. As future work, the authors intend to develop a tangible interface, able to recreate the corporeity, the materiality of the original interfaces: the inherent latencies between the user gestures and the corresponding effects on sound generation; the resistance and viscosity of the tape, which was slowed
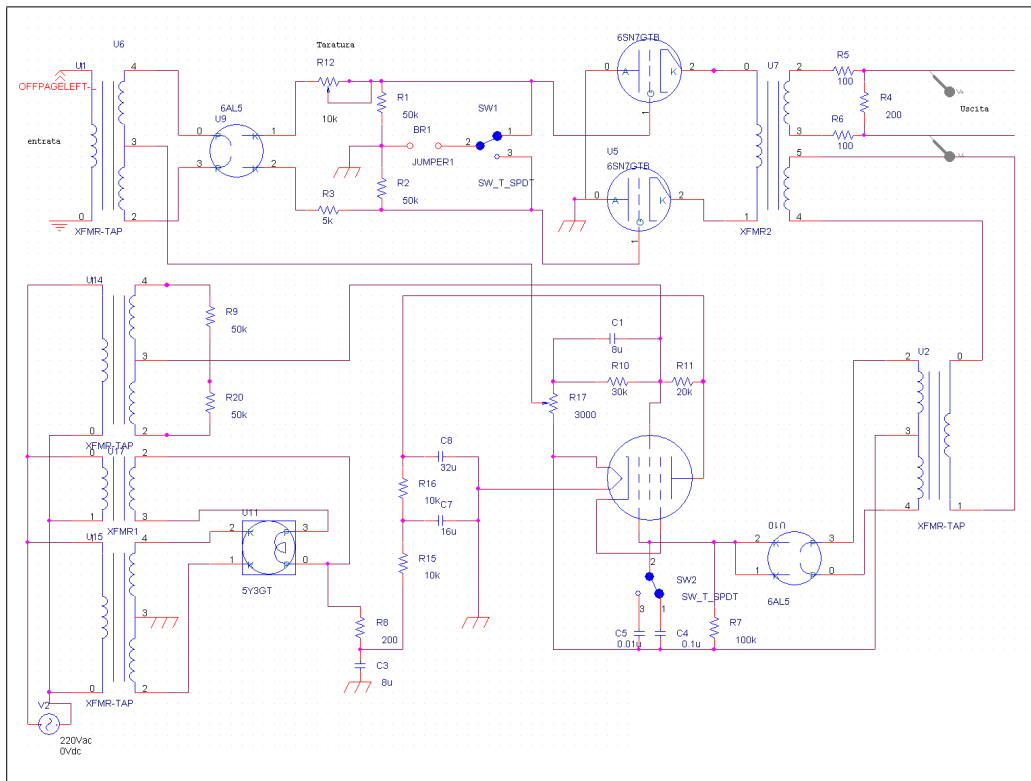
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Figure 7. Electrical scheme designed to simulate the device.

by hand by the composer-performer; and so on. All these physical characteristics influenced the composer and his way of interacting with the devices, and need to be preserved in their virtual counterparts.

6. ACKNOWLEDGEMENT

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