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Regenerative Feedback in the Medium of Radio: *Study 1.0 (FM) for Radio Transceiver*

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ABSTRACT

The author discusses compositional applications of feedback in the medium of radio as a means of exploring the nature of transmission and reception. His *Studies for Radio Transceiver* are presented here along with a detailed discussion of *Study 1.0 (FM)*. This composition juxtaposes the historical and technical use of feedback in radio with audio signal recursion. Regenerative feedback is used to redefine the compositional capabilities of the medium.

The *Studies for Radio Transceiver* (2001), presented here, join a tradition of creatively repurposing audio tools in order to explore the nature of media. A rich body of compositions using radio signals has been created, including John Cage's *Imaginary Landscape No. 4* (1951) for 12 radio receivers; Karlheinz Stockhausen's *Hymnen* (1965–1967) and *Kurzwellen* (1967), which used shortwave radio signals; and ongoing projects by musicians such as Holger Czukay and Robin Rimbaud (a.k.a. Scanner). These works notably concentrate on the reception of existing radio signals, focusing on collecting preexisting transmissions and in many cases juxtaposing and layering simultaneous unrelated and randomly occurring signals.

The *Studies for Radio Transceiver* expand on this work by examining the nature of radio transmission itself, the music being a byproduct of both the transmission and reception of an audio signal. In particular, the first in the series, *Study 1.0 (FM)*, considers the broadcast and reception of an FM radio system's self-noise; regenerative feedback is used here to redefine the compositional capabilities of the technology.

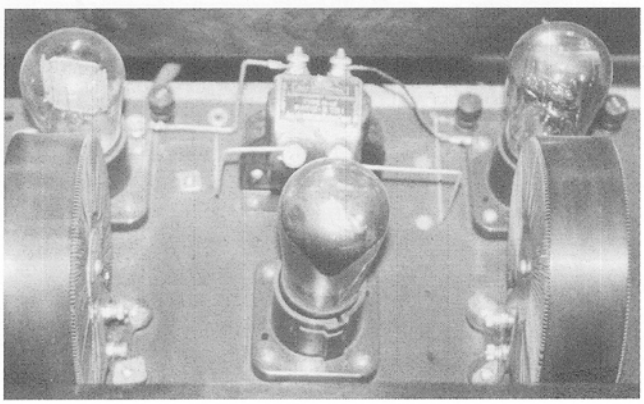
Transmission/Regeneration

The notion of information transmission is critical in the canon of 20th-century audio technologies. As an undergraduate at Columbia University, Edwin Armstrong studied Lee De Forest's radio tubes, which had been designed for the Marconi radio company. He altered the De Forest tube by feeding high levels of electromagnetic waves back through the tube and allowing the production of an independent oscillation, a process he called "regeneration" [1]. Armstrong's circuit describes regeneration of the electromagnetic waves, or "feedback," as a means of amplifying the signal until it creates its own continuously oscillating electromagnetic signal. Figure 1 shows a photograph of the inside of an Armstrong regenerative superheterodyne receiver of 1917 [2].

In 1933 Armstrong made another contribution to the technology of radio, creating the first working demonstration of FM. The FM transceiver increased the dynamic stability (and therefore the range) of the transmitted signal by modulating its frequency rather than its amplitude. Armstrong began making regular FM broadcasts from the top of the Empire State Building until he was forced to move out of New York City [3].

By redefining a transmission medium as an instrument, the composer may seek expression as the actualization of the medium itself. A medium such as radio, meant to capture and repeat human expression, brings with it the implication that a message is contained in the signal. However, despite the fundamental connection of radio transmission technology to feedback, this presumptively transmitted content is subverted if the signal is recursively fed back into the system. Signal regeneration allows the nature of the medium to take on primary importance, asserting itself into the audio content of the message. Thus, feedback points to the conception of the medium as an instrument, the process of signal generation becoming the signal itself.

Fig. 1. Inside view of the Edwin Armstrong Superheterodyne Receiver of 1917. Armstrong's modifications of Lee De Forest's tube are the basis for the technology used to compose the *Studies for Radio Transceiver*. The three-element tube allowed for the amplification of signals and production of radio signals. (Photo © Matthew Burtner)



The *Studies for Radio Transceiver*

Study 1.0 (FM) is the first in a larger series of *Studies for Radio Transceiver*, part of the *World Noise Radio Project (WNRP)*. This project questions the nature of the radio medium in general and particularly the role it plays in forming the content of a musical signal. It explores the alteration of sonic content as it is passed through a medium to a receiver.

The project was first defined in a lecture on the question of content and medium presented as a remote FM transmission to Brian Ferneyhough's composition seminar at Stanford Uni-

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versity [4]. In the conceptual art piece, WNRP, the medium of radio itself provides musical content. Accordingly, compositional content before transmission is minimized in order to focus on the properties of the medium through broadcast and reception.

The *Studies for Radio Transceiver* are best described by the score itself, which is a series of text instructions for realizing the pieces. The performable pieces of the group were first presented on 4 October 2001 as part of the *Strictly Ballroom* series' "Mechanical Music" concert at CCRMA, Stanford University. Each study exploits a particular aspect of transmission and reception through the FM medium.

Studies for Radio Transceiver
Matthew Burtner, 2001

These pieces can be performed in any order, manner.

Study 1.0 (FM). Transmit a silent signal. Receive the signal and feed the line outputs of the receiver back into the transmitter. A loop is created in which the listener hears the compounding of the inherent noise generated in the process of transference. The growth of the systemic noise moves from the periphery of the music, a byproduct of the media, to the central focus of the musical material. We hear the resonance of the FM band grow from noise, the intoning of the medium.

Study 1.1 (diffusion). Transmit a musical signal in a concert setting. The audience provides the sound system for the concert by tuning in on a variety of receivers to the specified frequency. The number, quality, and spatial positioning of the speakers create the sounding result, a result that, although fixed in transmission, will be diffused differently for each performance. The music in this context is a fragile signal that is "discovered" by the audience in real time as it is projected through the imperfect medium. A bond is formed between the music and the listener's sense of discovery and need to protect this fragile sound. The FM noise floor creates a sense that at any moment the signal could vanish into the noise forever.

Study 1.2a (net). Several performers, each playing a different radio receiver, are spaced throughout the hall. Each performer is assigned a range of the FM spectrum. They turn on the receiver and begin tuning it, within their range, to a frequency that falls on an unoccupied band of the FM spectrum. Once each performer has found an uncorrupted band, the noise web is established and held.

The activity seeks to uncover the "intact" fragments of a fractured FM band (88–108 MHz). By focusing on the unused parts of the bandwidth, a conceptual bridge is created between these cracks. A philosophical process of human erasure is attempted. The net strives towards emptiness. And thus the viewer perceives a negation of the haphazard distribution of sonic intentionalities across the airwaves. These isolated points on a frequency spectrum become ideological bridges over which we pass into an unoccupied, peaceful world.

In remote parts of the North, scanning the FM dial reveals that no human signals are being broadcast. The feeling provoked is one of aloneness, isolation, and vast spaces. By contrast, scanning the FM dial in populated parts of the world creates a feeling of acoustic claustrophobia. This piece attempts to use the real time noise net as a means of reconstructing a world of emptiness.

Study 1.2b (net). Once the net is established, the radio transmitter transmits a silent signal, and the performer freely alters the circuitry and broadcast frequency. The frequency modulation takes over each receiver in a different way, and a variety of radio sounds can be produced by altering the capacitance and antenna length of the transmitter, and by moving around the concert space. The "net" is heard as coming to life, each node evolving into a voice of its own, generating a polyphony of radio noises.

Study 1.3 (drift). Broadcast some recognizable music over the FM transmitter. As the audience listens to the transmission, the transmitter is gradually moved away from the receiver. The music at first is clear but gradually becomes noisier. On the fishing boats in Alaska, as the boat moved into a storm or down the coast, away from the transmitter, the signal would gradually disappear. I remember sitting close to the speaker, trying to catch the fading notes of a piece of music as it vanished without a trace into noise. Poor audio reception creates a sense of intimacy, like watching the last flames recede into embers in the fireplace. The impoverished quality and subversive noises on old records create a feeling of nostalgia. Similarly, any familiar medium that once served as a conduit for artistic perception evokes a sense of nostalgia. But nostalgia does not adequately express what is happening perceptually. This nostalgia is not simply a temporal longing, but also a material one. It is a feeling of closeness, depth, and intimacy to the work of art, brought about through the close listening experience created by the media.

Study 1.4a (WNRP). The World Noise Radio Project started as a series of site-specific "radioscape" miniatures, collected from different frequency spectrums from different locations around the world. My hope was to document the worldwide existence of a "noise radio," common to all people and places. In the context of WNRP, the radio noise became an analogy for peace, unity and equality. Theoretically, white noise (containing all frequencies at equal amplitude) forms a solid, non-acoustically partisan block of sound out of which any signal could be potentially carved. White noise contains, in theory, all possible musics, expressions and languages. By forming geographical, cross-cultural acoustic signifiers through the radio band, an acoustic worldwide unity is created.

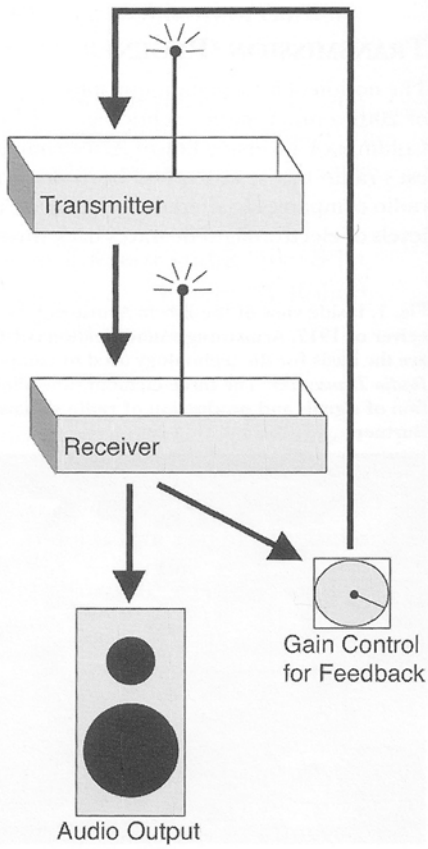
Study 1.4b (WNRP.net). Unlike the outback of Alaska, most populous areas are overcrowded and their radio bands are consequently polluted with powerful signal transmissions. Collecting unpolluted radio signals became increasingly problematic with WNRP. Therefore a new Internet radio station was formed that only broadcasts noise. Internet radio, unlike its analog, wireless companion, is suspiciously lacking in random noise. Degradation of quality is introduced as a byproduct of file encoding, but the medium lacks the inherent chaotic acoustic properties that characterize the signal of analog radio. A version of the Internet World Noise Radio Project was first broadcast (since September 2001) at <http://www.live365.com/stations/278291>.

Study 1.0 (FM) for Radio Transceiver

Study 1.0 (FM) for Radio Transceiver refers to Armstrong's work and the origins of frequency modulation by using feedback to amplify the signal properties of FM and of a specific transmission/reception circuit. The characteristics of the medium are revealed in the noise-to-pitch transformation brought about by the feedback system.

Study 1.0 (FM) uses gain control of the feedback into the circuit as a means of slowly revealing the properties of the system. A radio transmitter transmits an

Fig. 2. Electronics setup for *Study 1.0 (FM)* showing the signal path. (© Matthew Burtner)



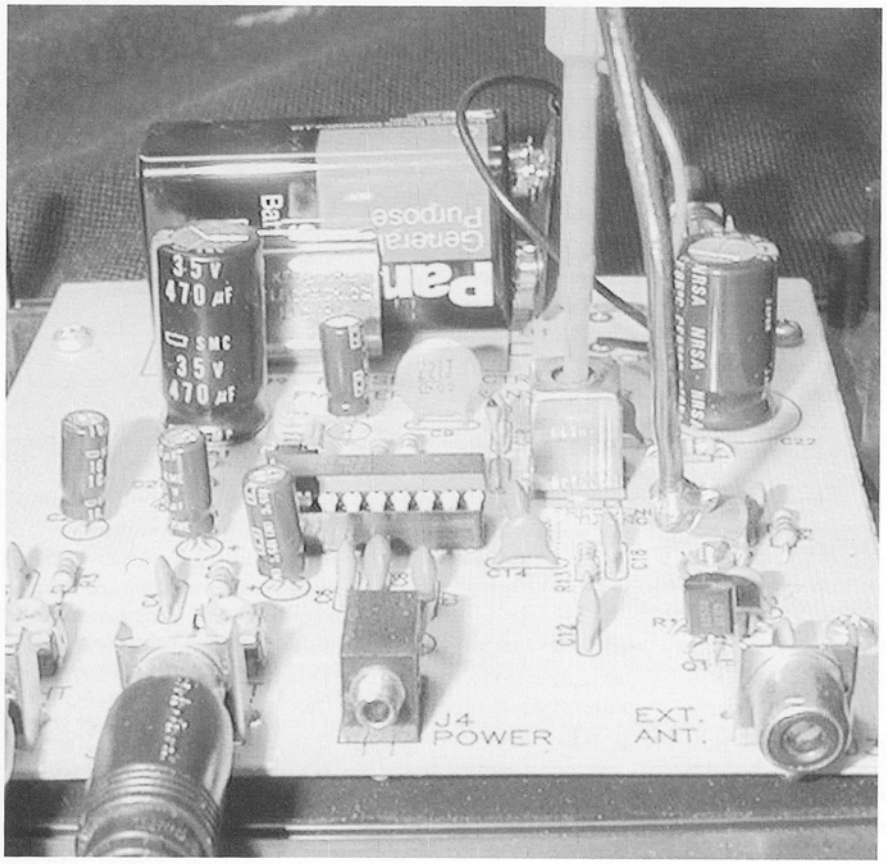


Fig. 3. The FM10A radio transmitter circuit board used in the first performances of the *Studies for Radio Transceiver*, 2001. (Photo © Matthew Burtner)

empty signal on a chosen band of the FM spectrum. A receiver is tuned to the same band and the output is routed back into the transmitter. By placing a gain control in between the transmitter and receiver, the amount of feedback signal can be controlled by a performer (Fig. 2).

Any standard FM radio transmitter and receiver will work; performances to date have used an 18-pin FM stereo-transmitter integrated circuit by Ramsey Electronics with a variety of off-the-shelf receivers. Composition of the piece focused essentially on building the FM transmitter circuit. The circuit acts as a homemade instrument or a type of score defining the path of electricity through itself. Performance of the piece is a gradual revealing of the properties of this circuit. The slow change of gain control to the circuit requires a type of concentration that focuses the performer's attention towards and into the circuitry of the instrument.

Two potentiometers allow adjustment of each channel of the input signal. The performer sets these carefully prior to performance to avoid distortion of the feedback signal. In performance, the musician controls the gain of the input to the transmitter with an external gain control, very gradually increasing and then decreasing it. The carrier signal of the transmitter inductor coil (IC) is set by adjusting the resonant circuit formed by the combination of a capacitor that sets the general transmission band and a shielded IC, which tunes the transmitter within that larger range. This is also set in advance of performance, the transmitter and receiver being tuned to the same, clear frequency. Power to the transmitter IC and to a Negative-Positive-Negative Very High Frequency (NPN VHF) transistor is regulated at 2.1 volts DC by three glass-bead diodes. The radio frequency (RF) output from the VHF transistor sends the FM transmitter carrier signal to an antenna socket. A long copper wire is soldered to the antenna socket protruding from the top of the circuit board (Fig. 3).

The sounding result is a gradual move from noise to a gentle intonation of a resonant frequency of the complete circuit. The performer changes the gain slowly, listening for feedback building in the system and making the slowest possible transition from noise to pitch. In this way, an attempt is made to focus the listener's perception of the noise characteristics of the FM medium and upon the properties of this particular circuit.

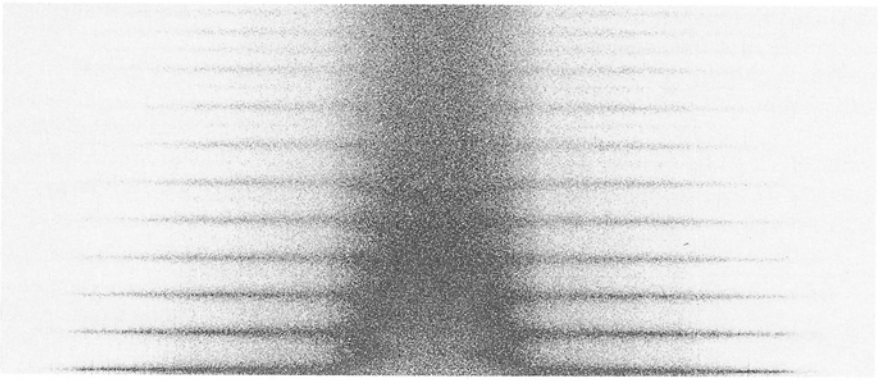
The transmitter circuit board is left open so that the performer can improvise by interacting with the circuitry during performances of the *Studies*. As the performer reconfigures the circuitry, partially shorting components in different combinations or changing the antenna length, unpredictable changes in the output signal can be produced.

Conclusion/Recursion

Figure 4 shows a sonogram of a performance of *Study 1.0 (FM)*. The image exposes the simplicity of the musical structure, almost iconically symbolic in form. Over the course of approximately 3 minutes, a harmonic tone of around 1,033 Hz gradually surfaces, becomes saturated into noise, returns to the pitched sound and then disappears into noise as the feedback is modulated.

Through this feedback process, the nature of the transmission itself is explored. Unlike the radio compositions of Cage or Scanner, the *Studies for Radio Transceiver* do not attempt to examine the sociopolitical convergence of radio signals. Rather, they circumvent human expression in these bandwidths in order to construct a unity *aside* from human expression. The pieces enter a territory

Fig. 4. Sonogram of the *Study 1.0 (FM)* showing the formal spectrographic evolution over the 3-minute duration of the piece. (© Matthew Burtner)



crowded with signal intentionalities and then avoid those signals entirely. Specific messages are avoided in favor of message potentialities, those found in the frequency-rich field of noise, out of which any potential signal could be shaped. The closeness of human transmissions in the FM band creates a signal crisis that generates the meaning of these pieces. They would be quite different pieces if the FM band were completely empty of human transmission.

Additionally, unlike the radio pieces of Stockhausen or Czukay, the *Studies* do not attempt to discover new sounds arising from random fluctuations of radio signals. Rather, these pieces point to the conceptual nature of media and the way signals are transmitted wirelessly across space. The conceptual aspects of transmission, here metaphorically embodied in FM, are more important than any resulting sounds. The negative space of sound (I do not mean "silence") is the material of this music. As such, the *Studies* evoke potentially vast and empty spaces. They struggle to keep the means of communication open in these spaces, problematizing current models for information transference.

In "La Radia," F.T. Marinetti and Pino Masnata wrote that radio "shall be . . . the synthesis of infinite simultaneous actions" [5]. In the *Studies,* it is through recursion and noise that the medium references this notion of infinite simultaneity. Feedback, so closely tied to the technology of radio, exposes a potentiality of the medium as a voice of its own. Antonin Artaud's statement that "all words, once spoken, are dead" [6] is confronted by the notion of recursion. The signal, once spoken, is not spoken at all; only through regeneration does the medium itself speak.

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