Chapter Title: Electronic Music Hardware and Open Design Methodologies for Post-Optimal Objects

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Book Title: Making Things and Drawing Boundaries

Book Subtitle: Experiments in the Digital Humanities

Book Editor(s): Jentery Sayers

Published by: University of Minnesota Press

Stable URL: https://www.jstor.org/stable/10.5749/j.ctt1pwt6wq.22

# Electronic Music Hardware and Open Design Methodologies for Post-Optimal Objects

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This chapter develops a brief historical and theoretical overview of hardware hacking within the context of electronic music instruments, suggesting how component-level analysis of some specific artifacts can help scholars to appreciate accelerating shifts in musical production as well as larger cultural trends. The chapter does not promote hardware hacking as an optimal solution for every musician. Rather, it recognizes hacking as a long-lasting and self-sustaining technocultural practice. This recognition is achieved in part by developing an adapted understanding of Anthony Dunne's "post-optimal electronics" (2005). Such understanding investigates what makes electronic instrument design unique, how each artist bends the traditions of engineering and fabrication for their purposes, and offers possibilities for relating audio technologies to our modern culture of invention. In short, taking a closer look at audio technology's technocommunal aspects informs modern trends in composition, invention, and scholarship.

The development of contemporary electronic music is closely related to the tinkering practices enabled by kits in early-twentieth-century industrialized countries.[1] Containing all the parts and instructions necessary to put together some electronic device, these kits allowed for reverse engineering to be a personal and possibly untrained experience.[2] Originally aimed at amateur radio enthusiasts, they evolved to provide people with accessible, simple, yet effective audio systems and, occasionally, instruments such as theremins.[3] In turn, hobbyist publications empowered young enthusiasts. For instance, Robert Moog and Donald Buchla started as teenagers building electronics kits, suggesting that electronic music is deeply rooted in the do-it-yourself (DIY) practices that made it possible.[4] It is only natural, then, for contemporary composers to engage directly with the physicality of electronic music by designing and building their own equipment or modifying existing devices. Developing a creative, experiential understanding of signal processing is one way, for example, to acquire an additional connection to the artifacts involved in music making.

With kits evolving from somewhat hazardous vacuum-tube circuits to inexpensive solid-state devices in the late sixties, the limiting factor for engaging directly and safely with electronics for music became dedication, not prior knowledge. Quoting Nicolas Collins (2006), "Rule #17: If it sounds good and doesn't smoke, don't worry if you don't understand it" (225). Educational publications also shifted from paper (electronotes and popular electronics)[5] to the network of online resources available to the electronics tinkerer today. Since schematics are often sufficient to produce a close equivalent of a device, even the early web message boards were good enough to enable amateur or small-scale circuit building.[6] Online information and advice on fabricating your own musical electronics have existed since the late nineties (one of the first posts on the diyaudio.com forum is dated from 2000). "It's never been easier to hack. . . . Tim Berners-Lee birthed the World Wide Web and a hundred fuzztones flowered" (228). The consequence of cheap tools, cheap parts, accessible information, and a lack of centralized authority is a variety of alternative visions for an exploded field of personal electronic music devices. Approaches range from respecting best practices outlined by engineering scholars to working purely by intuition,[7] with musically successful innovations coming from both sides of this spectrum. If Moog's machines helped to kickstart modern electronic music, then Buchla's instruments became essential to avant-garde composers such as Morton Subotnick, and entire genres are now based on specific hardware hacking techniques.[8]

A compelling instance is the work of Jessica Rylan, a former Buchla employee who founded the now-defunct Flower Electronics[9] brand in 2006 and ran it until 2013. Rylan's products included mostly standalone analog synthesizers, reminiscent of Buchla's colorful banana jack-wielding modulars[10] and David Tudor's unmarked electronics. Rylan's approach is explicitly an expansion of traditional circuit design. Describing her design methodology, she writes:

> During the period of time when I was designing circuits, I tried to incorporate a scientific approach into my design work. However, I used this strategy alongside other strategies including intuition, limitation challenges (for a year I didn't use an oscilloscope or a digital meter), and making design decisions visually (either based on what the components looked like, or how the schematic looked aesthetically). (Teboul Appendix 199)

Rylan's "personal synth" is full of small originalities at the circuit level that make it a unique, performable, and personal device. These originalities include voltage control of the wave-shaping circuit within the 8038-based oscillator, or a voltage controlled amplifier implemented with zener diodes, which exhibit nonlinear behaviors and allow for an unusual, nonlinear filtering characteristic. Such developments are materializations of an exploratory engineering—a multifaceted tinkering.[11]

Similarly, Ben and Louise Hinz of Dwarfcraft Devices[12] have developed a personal and commercially viable approach to audio-effects boxes and eurorack-format synthesizer modules. Starting from Collins's *Handmade* recommendations, a few years of experimentation led Dwarfcraft to become an appreciated brand. An early device, the "Robot Devil," contained a version of a Nic Collins circuit (Collins 155), itself obtained from Craig Anderton's (2003) formative publication (Anderton 173). In this case, however, most of Collins's advice was ignored and seemingly unusual modifications were made, with protection diodes removed and gain values set well beyond the recommended range. The result is nevertheless an original and usable device,[13] which is emblematic of many popular signal processing devices currently on the market.[14]

In effect, with each new device comes a new iteration of experimental design practice, a multifaceted and heterogeneous ecosystem for invention[15] based on what is accessible to the designer of the next step. Each step does not necessarily represent technological progress. Instead, it is the materialization of another personal vision of electronic music. Had the field of electronic instrument design had a clear direction or a more rigid structure (like amateur radio), this explosion of visions and methodologies arguably could have been stifled. However, the musical context surrounding these developments is important: loosening the assumption of what was "desirable" in electronic instruments came with a wider acceptance of musicians from various skill levels in both academic (Cardew's Scratch Orchestra, for example) and popular (or punk) forms of music.

This history and methodology draw clear connections with the open-source hardware community.[16] Actors and networks of actors are often comparable: tools are usually of the electronics, fabrication, design, and graphic variety; spaces include communal, personal, or professional shops; and the imagined communities usually solidify in online presences (forums and data sharing platforms, for instance) and occasional physical events, such as knobcon and the National Association of Music Merchants (NAMM). These connections do not necessarily suggest that open-source will develop splintered, local versions of technology, but they do offer precedents as to how creative minds approach technical freedom.

If the genealogy, reality, and legitimacy of these silicon luthiers,[17] or heterogeneous designers,[18] has been established, then consider the individuality of the auditory experience: the quality of a sound is determined by the listener based on internal factors (tastes) and external influences (context). As sound sources, instruments will be judged on similarly subjective, variable, and personal levels. That is, *the quality of creative devices is not reducible to a set of objective metrics* (such as the size, power consumption, and storage capacity for a hard drive). Those metrics may be of interest but must be considered alongside the experiential connection a person and their audience have to the artifact. Of course, extremely high-quality components may be used in personal instruments and may increase reliability or comfort; however, the persistence of vacuum-tube amplifiers[19] and analog synthesizers[20] attests to a tendency to become attached to "inefficient" technologies.[21] Theoretical discussions of electronic music instruments explicitly acknowledge the shortcomings or incongruities of hardware as ultimately inspiring for their designers and audiences.[22]

This concept of purposefully challenging people through design relates directly to Anthony Dunne's theory of post-optimal electronics: "if user-friendliness characterizes the relationship between people and the optimal electronic object, then user-unfriendliness, a form of gentle provocation, could characterize the post-optimal object" (Dunne x). Characterizing electronic music hardware as a class of post-optimal objects offers a tool to discuss the development of so many individualized visions of electronic music, as the term encapsulates much of what makes those devices catalysts of poetic experiences. Building your own electronic instrument, even if it is not necessarily the most technologically advanced tool available, provides an inherent personal connection, as well as an intuitive understanding of the device that might serve the interests of composition. Rylan notes that this connection is no guarantee of musical or technical quality, yet it can be inspiring and effectively open new compositional or performative paths (Teboul 200).

A post-optimal vision of electronic music also has ideological implications. Opening up, modifying, and copying devices should be justifiable if it can benefit the final artistic product, and yet the majority of available devices do not carry that ideal through their design: enclosures are often designed to prevent consumer servicing, and warranties are voided unless either the device is inspected by an approved technician or authorized firmware is uploaded. These restrictions force electronic instruments back into an "optimal" vision of technology, where better metrics justify replacements and minimize personal connections to devices. Such optimization mimics greater cultural trends of material consumption in industrialized economies.

Concerns in discussions of music technology, including discussions about authors, origins, interface designs, and their subsequent use/reuse/misuse, have been and continue to be addressed by scholars and scholarly organizations.[23] However, the technological components themselves are often ignored in these discussions. This inattention to components is important because electric instruments and the artifacts they contain are embedded with personal connections to their original designers. Electronics are possible only because of an industrialized and standardized manufacturing market premised on individual labor. In this market, the building blocks of instruments are largely shared from one device to the next, through components (such as resistors, capacitors, inductors, and transistors[24]) as well as circuits (consider "standard circuit" topologies discussed in electronics textbooks[25]). These dependencies explain the sensation among audio electronics designers that entirely novel designs are extremely rare, and they further justify the connection with open-source design: if most audio devices are a new take on an old concept, then acknowledging lineage is ethically preferable to claiming originality. It is also instructive.

The underlying paradox of techno-artistic practices is that engaging with the physicality of electronic music is an important source of inspiration and motivation for practitioners. The works of David Tudor, his students, and a variety of contemporary practitioners from Peter Vogel to MSHR (Birch Cooper and Brenna Murphy) attest explicitly to this inspiration.[26] Breaking down the black boxes of electronic music has motivated the creation of many pieces across the professional-accessible spectrum. Yet few practitioners acknowledge how the subsystems they make explicit all contain personal connections to components made by other designers. The original intentions for those small elements, circuit topologies, and associated materials all subtly influence the system in which they are used, even if they are co-opted. Dealing with these components directly, instead of relying on graphical user interfaces or computer screens, also helps practitioners to better understand subsystem functionalities and their histories. For instance, consider how the liner notes by engineer Forrest Warthman for Tudor's *Neural Synthesis* (1995) offer extensive insight on the genesis of the piece itself and its technological significance precisely because they discuss the components involved. The notes cover the development of the chips used to simulate neuron functions and how Tudor's creative intuition guided the project. Warthman includes the following comment on the links between music and technology:

> Audio oscillators have a subtle but long history in Silicon Valley. Many local engineers date the beginning of the semiconductor industry to the 1938 development by Bill Hewlett and David Packard of their first product, an audio oscillator, in a downtown Palo Alto garage.[27]

With such a fortuitous connection, the details of individual components appear all the more important. Who designed the components? In which system were they were originally used? How were they packaged? Why did resistors evolve from carbon compositions to other materials? Can these subsystems be approximated with alternatives that are interesting to practitioners?

These concerns may seem superfluous; however, this care for low-level detail is primordial in some of the professional audio world. It is also central to post-optimal electronics. Recording and mastering engineers often spend a considerable amount of time experimenting with capacitors for a particular section of a filter or amplifier. To them, those choices matter, and the quality of their system is a significant element of their professional reputation.[28] By becoming more aware of the origins and implications of the component choices, musicians can expand the connection between a particular device and its sonic products. The framework of post-optimality therefore shifts the conversation from a technical level to an experiential one, opening a discussion that is often mired with elitism ("a professional degree validates your opinion") and classism (for instance, the sound systems associated with component-level care are expensive).

Ultimately, then, this chapter extends the current exchanges on electronic instrument design by widening the focus to personal relationships and acknowledging the deep intuitive understanding many gain through experimentation, without abandoning a parallel genealogy of the musical systems and individual components that make them. This sociotechnological understanding of electronic music hardware is in many ways related to previous, more generalized accounts of invention,[29] but those sociological or historical studies rarely deal directly with circuits. Post-optimality and poetics serve this vision by demonstrating how technologies facilitate tasks in a variety of ways, some of which need not involve scientific progress or innovation. Musicians and audiences are unique, and the objects that bind them together benefit from crystallizing that uniqueness through attention to context.

## NOTES

1. In effect, homemade electronic music inherited kit culture's traditionally white cis male population. See Haring on radio and Rodgers on music technology as traditionally gendered spaces.

2. For more on the culture of kits, see Haring, Chapter 7.

3. Theremins are particularly emblematic of the history of electronic music. Also, Moog began his synthesizer business by selling assembled versions of kits. For more on Moog and Buchla, see Pinch.

4. For a history of making in musical electronics, see Teboul, Chapter 2.

5. Archives available at http://electronotes.netfirms.com and www.americanradiohistory.com/Popular-Electronics-Guide.htm.

6. See diyaudio.com, diystompboxes.com, and synthtopia.com alongside schematic websites such as www.hylander.com/moogschematics.html. A proper discussion of the particularities of intellectual property laws relative to copying the functional elements of musical devices is beyond the scope of this chapter. For an informal discussion, see www.muzique.com/clones.htm.

7. For a discussion of various philosophies of circuit bending, see Ghazala.

8. See Collins; Kelly; and Novak.

9. See Rylan et al. at www.flowerelectronics.com.

10. See www.buchla.com.

11. For a more complete analysis of Rylan's "personal synth," see Teboul, Chapter 3, Section 2.

12. See Ben and Louise Hinz at www.dwarfcraft.com.

13. For additional details and references, see Teboul, Section 3.3.1. For an in-depth analysis of musical electronics as post-optimal objects, refer to Teboul, Chapter 3.

14. See, for instance, the Earthquaker Devices Bit Commander, the Death By Audio Robot, and the Electro Harmonix Octave Multiplexer.

15. The biological connotations of this term appear particularly appropriate considering the real-time, personalized and fragile nature of the communal platforms that empower homemade electronic music, echoing Eriksen's use of the word mushrooming (24). The online instrument maker communities are born, evolve, invent tools, influence each other, develop points of view, die, and leave artifacts behind that slowly decay.

16. See Gibb, Introduction.

17. See Collins; and Teboul.

18. Heterogeneous designers are a creative version of Law's Heterogeneous Engineers (see Law in Bijker).

19. See Barbour; and Hamm.

20. See, for example, the panel discussion at the San Francisco MusicTech Summit on May 17, 2010, archived at https://archive.org/details/ResurgenceOfAnalogSynthesizers.

21. For an in-depth discussion of cultural change as an alternative to technological progress in addressing functional imperfections (reverse salients), see McSwain in Braun.

22. See Rovan discussing Evens (2005).

23. See Pinch; Kelly; Rodgers; and Novak.

24. This is most obviously exemplified by the integrated circuit, a packaged and unmodifiable black box.

25. For example, consider topologies for comparators, integrators, negative feedback-based operational amplifiers, and Darlington pairs. See Horowitz, Hill, and Hayes; and Langford-Smith.

26. See Collins; and Issue 14 of the *Leonardo Music Journal* for a practical history of examples.

27. See www.davidtudor.org/Articles/warthman.html.

28. See Teboul, Sections 3.8, 4.9, and A.1 for an in-depth discussion of the topic based on an interview with Sang-Wook Nam, mastering engineer.

29. See specifically the literature emerging from Bijker's work.

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