

A Look Inside *Electric Guitar—Sound Secrets and Technology*

New book hits the right note for both musicians and technicians

Electric Guitar—Sound Secrets and Technology

Helmuth Lemme
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In his book, *Electric Guitar—Sound Secrets and Technology*, Helmuth Lemme addresses the average consumer/musician who is technically interested in and familiar with certain fundamentals of electronics (see **Photo 1**). The communication between musicians and technicians is often difficult. He wrote his book as a bridge between these two worlds. A cult following has arisen around certain electric guitars and basses that has been crafted in part by clever marketing and sponsorship by popular performers.

Advertising works on an emotional level and glorifies consumer products. While every musician wants to have the best sound, it is possible to improve on many commercial instruments for little money. It just depends on the application of accurate and proven knowledge. This book aims to expose the fictitious, idolized world and bring it back down to earth.

THE FOUNDATION

Chapter 1 presents a concise yet comprehensive historical review of the breakthroughs and development of all types of guitars—from traditional Hawaiian guitars to flat-top classical, full-body archtops, solid body, and semi-acoustic guitars. This chapter also has a section on electric basses.

Chapter 2 gets into the real substance of the book—how the strings, body, neck, frets, bridge, and all their various mechanical resonances determine the guitar's sound before any electronic

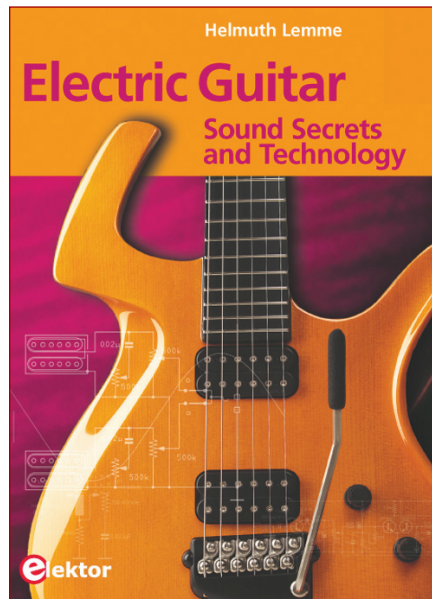


Photo 1: This book (available at www.elektor.com) explores the guitar's mechanical and electrical parts. Manufacturer's secrets are unveiled, pickups and their electrical environments are explained, and several tips for the technically inclined musician, can improve the sound for many instruments.

components are added. Other factors that influence the guitar's acoustic sound are room acoustics, any venue amplification that may be used, and even the way a guitarist holds and plays the instrument.

PICKUPS

Chapter 3 is the book's longest chapter, and the author aims to demystify magnetic pickups. A pickup creates an electrical signal with its own transfer characteristic by absorbing vibration energy from the guitar. The fine nuances are defined by the mechanical properties examined in Chapter 2.

A poorly constructed guitar cannot be improved by even the best magnetic pickup design. I learned that when I naively tried to electrify a cheap archtop when I first learned to play guitar.

I obtained two "lipstick" pickups from the nearby Danelectro factory and cut holes in the top of the guitar (and some of the bracing) to mount them. The guitar howled from 60-Hz hum and acoustic feedback when I plugged it into my small guitar amplifier. The feedback may even have been damped somewhat by the heavy layers of Testors Candy Apple Green plastic model spray paint I had applied to the body.

My next naive indignity on the now-mangled archtop was to try to make it into a bass guitar using the Guild humbucker bass pickup and bridge that I purchased from a long-forgotten commercial supplier. I filed notches in the nut to enable four bass strings to reside in the space once occupied by six guitar strings. I traded some of the resulting fret buzz for loss of intonation by adjusting the truss rod so the fingerboard was seriously concave. The neck eventually folded upward due to the structural damage I created with these modifications. But I digress.

The magnetic pickup market is competitive and diverse. The designs for magnetic pickups are equally diverse. The first magnetic pickups were single-coil, followed by the dual-coil Gibson humbucker. Lemme discusses the many different single-coil and humbucker types available. While "vintage sound" is hyped as highly desirable, the manufacturing and processing quality was highly variable in the early days.

The magnetic pickup electrical transfer characteristic is that of a parallel L-C circuit with the significant wire resistance in series with the inductance. This gives each magnetic pickup its own resonance frequency and high-frequency peaking due to the Q of the coil. The author calls this response peaking the "superelevation" characteristic, and it can be affected

by the volume and tone control resistances, the guitar cord impedance, and the amplifier's input impedance.

The author describes in detail the equipment and techniques he has developed to objectively measure the response of guitar and bass magnetic pickups. This gives the reader the electrical parameters needed to optimize the guitar's sound by simple modifications to the guitar's electrical components, cord, and perhaps the amplifier input circuitry.

Lemme also noted measurements of the important parameters of many common guitar pickups (e.g., Fender prints the coil inductance on the bottom of its pickups). These parameters are determined by the number of wire turns on the coil, whether it is a single-coil or humbucker, the flux density and reverse permeability of the magnet, the effect of the steel pole pieces and pole adjustment screws, metal pickup covers and plating, and so forth.

He discusses the linear and nonlinear distortions that are produced by these parameters in conjunction with the interaction of the pickup magnetic field and the vibrating strings, the type of string (e.g., wound or plain) and the physical location of the pickup or pickups in the guitar.

He also discusses the installation of active pickup preamps in the guitar, which can be a very effective method to achieve reproducible sound by isolating the pickup from the control pots, guitar cord, and amplifier impedances. Of course, this active circuitry requires electric power in the form of one or more 9-V batteries.

While there are a variety of commercially available magnetic pickups, section 3.9 in Chapter 3 is devoted to DIY construction and modification of magnetic pickups. DIY repair or rewind makes sense for unusual vintage guitars with no available replacement pickups or for extending the treble response of a top-quality acoustic guitar.

Chapter 4 has a relatively short explanation of the construction, operation, and electrical properties of piezo pickups.

Chapter 5 examines the positioning of a pickup or combinations of pickups on the guitar body. The tone is different for every position on the body, warm at the neck and harsher treble at the bridge.

Also, the resonance and impedance will change depending on whether pickups are connected in parallel or series. The harmonics are determined by the location of the pickup poles relative to nodes and peaks in the string vibration.

Incidentally, the Guild bass pickup I attempted to use on the previously mentioned archtop guitar eventually found a happy home on a 1967 Hagstrom bass guitar that I modified after learning a whole lot more about pickup position relative to the bridge and neck.

GUITAR WIRING

Chapter 6, the second-longest chapter, addresses guitar wiring. Lemme explains the advantages and weaknesses of both classic passive circuits and the passive circuits used in modern guitars. He explains why the resistance and connection of the volume control is the most important factor in resonance peak and superelevation.

Next, he presents a number of improved passive wiring circuits that enable the tonal qualities of the pickups to come into full effect. Good sound is a matter of individual taste, and the author's ideas are meant to encourage experimentation. Modifications range from extensive custom changes to those that retain the instrument's original appearance, and are easily restored to the original circuit design (assuming you had the foresight to keep the removed components).

Active electronics are a necessity with piezoelectric pickups. The author delves into active pickup design, which has the advantage of more tonal variety corresponding to state-of-the-art electronic design.

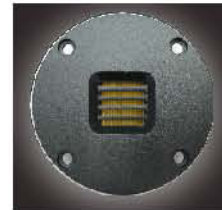
Lemme offers a number of DIY active electronic designs, and finished units and kits are available commercially. Active controls take up more space and require a battery compartment. He discusses the desirability of changes that can be completely undone without a trace. He also discusses good grounding and shielding techniques and describes how to solve hum and noise problems in both active and passive pickups.

Finally, Chapter 6 ends with a discussion of wireless RF transmitters.

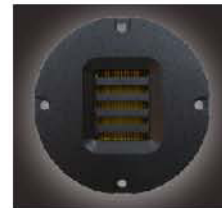
Chapter 7 briefly covers guitar synthesizers. Organ guitars were the



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predecessors to modern analog and digital guitar synths. While these devices all produce a wide variety of synthesized sounds, the "feel" of a guitar is hard to imitate and can be lost. Some manufacturers have developed modeling synthesizers that use samples of real instruments to get closer to the original sounds of vintage and modern guitars and basses.

FEEDBACK

Chapter 8 discusses feedback in electric guitars. The sensitivity to feedback is very low with solid-body guitars and increases with semi-solid, semi-acoustic, archtop, and flattop classical guitars, respectively. Feedback can occur due to microphonic magnetic pickups, magnetic fields from speaker magnets or power transformers in the amplifier, or pickups that are poorly fastened to the instrument. Sometimes it is desirable in rock music to have some sustain. The author also reviews electronic sustain devices (e.g., the Sustainiac and E-Bow).

MODIFICATIONS

Chapter 9 is entitled "The DIY Electric Guitar." Lemme describes how to repair electronic guitar components and how to perform the difficult removal and reinstallation of pickups, controls and jacks in semi-acoustic guitars. (I would love to have had this information when I wanted to replace a noisy tone control in my Gibson ES-335.)

He also discusses changing out pickups, improving pickups (including making entire pickups from scratch), and installing additional pickups on your guitar. He does not cover repairs to wood, neck truss rods, varnish, or hardware in this book. Lemme feels there are other good books that specialize in these topics.

DIY DESIGN

Finally, Lemme discusses making your own electric guitar. There are unfinished body/neck kits available, or you could use the neck and body from donor instruments (not necessarily from the same one). The solid-body guitar project is the easiest to undertake. The pickups, hardware, and electronic components are readily available. He describes the solid-body

12-string guitar he made from a reshaped Framus body, Ibanez neck, and custom-designed electronics.

GUITAR COLLECTIONS

Chapter 10 discusses guitar collecting as a passion, and how to select a suitable used guitar or bass. The high prices of older collectible guitars have kept many guitarists from being able to afford the guitar they might want. But over the past few decades, these high prices have also driven up the quality standards for new guitars.

The machine-wound pickups on new guitars are uniformly consistent. The hand-wound pickups on older guitars vary widely in number of turns, inductance, magnet strength and polarity, and winding consistency. As a result, one older guitar may sound radically different from another "identical" guitar due to pickup differences, as well as the amount of usage, and exposure to extreme temperature and humidity conditions. There is also the danger of fakes or altered units made to appear to be real classic collectible guitars or basses.

Chapter 10 also provides an extensive discussion on the mechanical and electrical test you need to perform before buying an instrument.

Chapter 11 presents tips for buying. You have to try a guitar before you buy it. This makes buying by mail order or over the Internet riskier, and Lemme does not recommend it. Playability and good sound are the most important factors in buying a guitar. Famous brand names are not always a guarantee of quality, and a no-name instrument may have the high quality you seek. Ignore advertising and sponsorship, any reference to "vintage," or fluctuations in the value of the instrument you ultimately choose to own.

THE BOTTOM LINE

I found this to be a fascinating and valuable book. The author is an experienced electronics professional and an active musician. He has thoroughly tested everything described in this book, in practice. In my opinion, the index is a very important part of any book, and a generous 15 pages are devoted to indexing. This book is highly recommended! *aX*