Section II

1. Hardware Components

Design and Function

WIRING

You probably know of + (positive) and – (negative) electricity terms and you probably also heard of electrically grounds. Electrically grounds are really just about as simple as these few terms.

Fig. 25 shows a coil of wire and a magnet, this makes an elementary pickup. The coil is wound from one long piece of wire so naturally it has two ends. One end can be used as a ground and the other would be the live lead or “hot” wire (it doesn’t really get hot, it’s just a term for aliveness.)

On a pickup, either end of the coil winding could be ground or hot. Generally, however, the wire that comes out of the center, or inside, of the coil can be the hot wire and the end that becomes the last winding on the outside of the coil becomes the ground, but this order can be reversed. If the outside wire is a ground, the general consensus is that this produces a shielding effect.

A pickup company usually gives a clue as to which wire is which by coloring leads attached to a pickup. The common electrical color for a “hot” lead is red, and the common color for a ground lead is black. However, not everyone follows that practice. For example, Fender often uses white or yellow for a hot lead and black or blue for a ground. Gibson often uses white for a hot lead and black for a ground wire. Other companies may use any color such as green or purple for a hot or ground lead.

Grounds

Gabson humbucking pickups are simple to figure out when taken apart. There are little black and white wires coming out of the two coils which are all inside the sealed case and can’t be seen from the outside. Only a single coaxial wire coming out of the case is visible from the outside and this wire is attached to the coil wires. The outside of coaxial wire should always be the ground so it can encircle and shield the hot lead.

The following information about grounds was written by the author for Schecter and is reproduced by their permission.

Electrical circuits use negative and positive voltages. If there is a positive voltage there has to be a negative voltage to complete the circuit. Very closely related to this is the balanced situation of having one hot lead and one ground. This is the setup in an electric guitar (or bass). For an electric guitar to work, the hot lead must not have any breaks in it, and the ground circuit must not have any breaks in it. These two leads go from the pickup, through the controls, to the output jack, and are then cabled to an amplifier. The ground lead is the foundation and security of a circuit.

Diagram used to depict grounds.

Solder connections for grounds.

A conductive ground plate used as inter-connecting ground circuit. This system can be used if metal-encased pots are used. If plastic-encased pots are used you will need to add a ground connection like that shown in fig. 3.

Ground connections are “common” connections. That is, all ground connections of a circuit are to be connected to each other, they join together in a commonly shared network. These interconnections of ground junctions (also called ground joints) can take several forms. The simplest method is to just have a single bare wire soldered from one ground point to another. Another method is to use a grounding plate to make interconnections. A grounding plate is a flat piece of metal onto which switches (or basses) controls are mounted. Ground points are soldered to the ground plate using the shortest wiring routes. For example:

1. The ground wire from a pickup can go to the ground plate.
2. The ground lug of a pot can be simply soldered to the back of a metal encased pot (if a metal cased pot is used). Since the pot is bolted up against the grounding plate, the metal case of a pot can provide the needed links between the lug on a pot which needs to be grounded and a ground connection.

This method of wiring saves time and money since no time needs to be taken to solder a separate ground connecting wire. The use of a grounding plate can look odd. There is a tendency to wonder where the ground connections are. This is of particular significance when it comes to wiring an output jack. A standard output jack has two lugs for connections. One for a hot lead, and the other for a ground lead. When a grounding plate is used there is no need to solder a ground wire to the ground lug on an output jack. The bolting of a jack against a grounding plate creates the needed ground connection. Still, it does look odd to many people when they see a jack lug with no obvious connection.

When a grounding plate is used it is very important that all controls are bolted tightly to the grounding plate. If a component is loosely fastened it can cause a poor connection point which in turn causes hum, cracking, or no sound at all. There must be a complete unbroken path from the ground point (wire) of a pickup all the way through to the output jack.

Color Codes

No two guitar electronics companies totally agree as to how to color code wires, i.e., what color the hot lead wires should be and what color the ground wires should be. White, yellow, and red are commonly used as colors of the insulation on hot leads and black is used as the color of the insulation on ground wires. There is no universal color code due to such variables as magnet orientation and direction of coil winding because when you invert the function (such as changing the direction of magnetic orientation) you could make a hot lead on one pickup behave like the ground lead on a similar pickup. For this reason, it is not advisable to rely on color as wiring clues.

The most important point about color codes is to understand what it is supposed to represent. Color codes are a short cut to help in manufacturing and consumer use. That is, it’s a helpful tool only if you stay with one company’s products; but if you want to use a Schecter Z+ Superock Omni Pot control harness with a DiMarzio Super Distortion pickup and a Lawrence L-500RTS, you will have a problem. These companies do not feel they should have to provide information regarding how to mate their company’s products with another’s. Hence, it is up to you to determine the color leads in the DiMarzio and Lawrence pickups and how they correlate to the color leads of a Schecter Z+ Superock pickup in order for the pickups to mate to the Schecter Omni Pot harness. To successfully interface, i.e., combine, different companies’ pickups and switches you must know the following:

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a. Which color lead is the start of coil #1?
   b. Which color lead is the end of coil #1?
   c. Which color lead is the start of coil #2?
   d. Which color lead is the end of coil #2?
   e. Which color lead is the ground lead.

Pickups are made with one of several basic wiring configurations. There are two ordinary lead configurations for single coil pickups, and six general lead configurations for humbucking pickups. The number of leads from a pickup can vary from two to eight. The more leads a pickup has, the more tonal options it can produce. When using a basic two lead pickup in a complex circuit, it will be necessary to add multiple leads to facilitate wiring. The following list can help determine what type of wiring configuration is on a pickup and what kind of coax wiring possibilities can be achieved.

LEAD WIRING ON A PICKUP

Single Coil Pickups

Determining the function of a single coil pickup’s leads is easy because of the limited number of leads and the visibility of the connections.

I. If there are two leads, one of the leads is hot and one is ground. Sometimes these functions can be inverted so an out-of-phase sound can be achieved when a second, normally wired, pickup is used. Sometimes inverting the function of the leads can produce a grounding problem. Exchanging the magnets is the best way to find out. A manufacturer is the best source of information as to which wire is which. The ground is generally in contact with the magnet, however, and touching the magnets can be a good test to see if the correct lead is connected to a ground point. If a pickup is properly grounded and it is touched on a magnet (or case) there should be less, not more, hum.

Fig. I (b) Single coil pickup.

Fig. I (f) Single coil schematic.
HARDWARE COMPONENTS

2. If there are three leads, this would be a tapped pickup. One lead would be full coil, the second would be the tap, and the third would be the ground lead.

Fig. 120 Tapped coil schematic.
Fig. 121 Tapped pickup

Humming Polups

a. One way to determine the function of each lead of a pickup is to take a pickup apart and find the origin point. Sometimes it isn’t possible to take a pickup apart (e.g., an encapsulated pickup) to inspect it. This problem is of little importance if you have an ohmmeter which can be used to measure d.c. resistance and so deduce the internal wiring of a pickup. Use the following steps as a guide for investigating common humbuckers.

1. If a pickup has a single coaxial lead, the braid connects to ground and the center lead is hot.

Fig. 122 Pickup with one hot lead and coaxial ground.
Fig. 123 Schematic of pickup above.

2. If there is a shield with two internal leads, this means that the leads are the ends of two series linked coils of a humbucker. This wiring allows in-phase or out-of-phase switching.

Fig. 124 Pickup with two hot leads and braided ground.

The following method can be used to determine the function of three hot leads plus one shielding lead wiring:

a. If one of the leads has a zero ohms connection to a metal bottom plate, magnet, or pole piece, that lead is ground. This lead should not have a connection to any of the remaining three leads.

Fig. 125 Schematic of Fig. 124.

b. Now hold the black probe of the ohmmeter on one of the leads and touch the red probe to each of the two remaining leads. If one of the leads gives a d.c. resistance figure of exactly one half of the other, that lead will connect to the junction of both coils. If both leads give the same reading, it will mean you have the black probe connected to the coil’s junction.

4. If there are four leads plus a shield, all the wires are then accessible for a normal humbucker. Two wires will be the ends of the second coil. This is easy to isolate with an ohmmeter. This wiring combination (4+) allows all wiring options without creating phase and grounding conflicts with another pickup.

Fig. 126 Pickup with three hot leads and bare wire connecting to foil ground.

The following method can be used to determine the function of four hot leads plus one shielding lead wiring:

a. If one of the leads has a zero ohms connection to a metal bottom plate, magnet, or pole piece, that lead is ground. This lead should not have a connection to any of the remaining four leads.

b. Now hold the black probe of the ohmmeter on one of the leads and touch the red probe to each of the three remaining leads. Two of the leads will give an infinite-ohms reading, and one of the leads will give a d.c. resistance reading of 1,000 to 6,000 ohms. The two leads that give the 1 to 6K reading will be the start and finish of one coil.

c. The remaining two leads should give a reading like the two leads of step #2. These remaining leads will be the start and finish of coil #2. You have now determined the function of all five wires.

d. To determine the phase of the two leads of each coil, use the phase test. This test will assist you in choosing which two leads are positive and which two leads are negative; however, it can not tell which wire is from the inside of a coil, or which wire is from the outside. It takes very specialized equipment to determine this. If a pickup can not be taken apart, and you can not contact the manufacturer for specifications either lead can be used as the hot lead or ground lead. In most cases a pickup can operate all right with the hot lead connecting to the innermost coil winding; however, sometimes this wiring can result in excess hum. If this is the case, reverse the hot and ground connections.

Fig. 127 Schematic of Fig. 126.

GUITAR ELECTRONICS

5. If you have six or seven leads you are likely to have a tapped humbucker which has three leads from each coil plus a possible ground lead from the case. A tapped humbucker would allow you to achieve about a dozen tonal variations.

6. If you have eight wires, you have a Bartolini Beast style humbucker. This pickup has two coils each with two separate windings. To better understand this see the section on Bartolini Hi-A pickups.

Fig. 128 Pickup with four hot leads and bare wire connecting to coil ground.

Fig. 129 Schematic of Fig. 128.

Fig. 130 Pickup with six hot leads and a bare wire connecting to a foil ground.

Fig. 131 Schematic of Fig. 130.

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Fig. 132 Bottom of a Bartolini Beast showing eight connection pins.

Fig. 133 Schematic of Fig. 132.

POTS

The Function of a Potentiometer

The device behind those volume and tone controls on your guitar are potentiometers; called pots for short. A pot is a variable resistor with three lugs.

A pickup could be wired directly to an output jack but, nearly everyone would like the convenience of having volume control on a guitar. A pot is put in the line to regulate resistance of the flow of current from
HARDWARE COMPONENTS

linear pot the ear would hear a sudden rise in volume which would level off as the pot was turned up. For this reason, audio taper pots are made. Their resistance change is made to conform to the hearing of the ear so that a steady increase in volume can be heard as the pot is turned up. Another reason audio taper pots are used is to ensure that the pot operation will create a non-leakage of current to ground (i.e., the third lug) when the setting is turned all the way up.

Pots can be obtained in many resistances, values from 10 ohms to 1 million ohms are used in standard devices. Electric guitars commonly use either 100K, 250K, 300K, 500K or I MEG ohm pots. The resistance value of a pot is related to the output of a pickup. High output pickups normally use high ohm resistance pots. The 100K (or other value) ohm refers to the total resistance when a pot is shut off. The K means to multiply by 1,000, MEG means to multiply by 1,000,000; therefore, 100K ohms means 100,000 ohms. The value of total electrical resistance of a pot is very important because if a pot is too high in resistance, the resistance curve will be erratic. Things have not become very standardized in this respect. Single coil pickups like Fender’s can adequately use 250K ohm pots. Gibson’s humbuckers are more powerful pickups and used 500K pots for many years. After 71-73 Gibson began to use 300K volume pots and 100K tone pots. Gibson made this switch so that their guitars would have a better, less treble sound. However, many people now use 1 meg pots as a perfect multi-purpose pot.

Pot Turning Directions

Pots for right-handed guitars are wired so that volume, or flow, increases as the knob is turned in a clockwise direction. Note that normal audio taper pots are made so that the taper functions correctly only in one direction. When the pot turns up volume in a clockwise turning of a knob, it’s correct. If you want an audio taper pot to work in the reverse direction you need a reverse audio taper pot. Remember that when you look at the bottom of pots when doing repair work, you will then want the turning action to turn in a counterclockwise direction, this is done so that when the pot is inverted it will turn in on a clockwise direction.

Notice that there are three projections coming from the case of a pot, these projections are called lugs. The center lug goes to a wiper blade that slides along the carbon path. The other two lugs connect to each end of the carbon path. Because these lugs represent the extremes of the path, the d.c. resistance value of the pot will be the same as the d.c. resistance between these lugs.

To understand how a pot functions, hold the pot in front of you with the lugs pointing down and the shaft facing away from you. Now turn the shaft in a full clockwise direction. This will electrically connect the center lug with the lug on the left. If there is an input from a pickup going to the left lug, and an output to a jack from the center lug, the pot will then turn for 0° in a clockwise direction. See the three drawings. In drawing #1 the pot is full “on”. Drawing #2 shows the wiper of the pot exactly half-way between the right and left lugs. In this position the pot is half “on”. In drawing #3 the clockwise rotation of the shaft results in the pot being turned off. Note: These illustrations and examples are diagrammatic, not working on a pot while looking at the back. From the front of the pot, a clockwise motion turns the pot “on”.

VOLUME POT OPERATION

Fig. 137 Volume pot wiring.

To better understand the actual operation of a volume pot, refer to the preceding three drawings depicting a pot turned on, halfway, and off. An actual volume control in a guitar will have the lug on the right wired to ground (when viewing the back of the pot). As the pot is gradually turned off, two things happen: First, resistance between the input and the output increases. Secondly, resistance between the output and the grounded lug decreases. Therefore, when a volume pot is turned off, a guitar is silenced primarily because the hot lead is shorted to ground, NOT because resistance has blocked the flow between input and output.

Fig. 136 The operation of a pot. (1) Pot is turned ON. (2) Pot is turned half way. (3) Pot is turned FULL OFF.

Types of Pots

Once there were only a few good pots made; today there are many. The following describes a good pot:

1. The conductive path inside a pot must be completely smooth - rough spots cause noise.
2. The pot should be sealed to keep out dirt and grit because contamination will make the pot crackle when it is turned.
3. The shaft should turn smoothly.

One feature that would be nice to have on a pot is a plastic shaft on which the knob fits. Unfortunately, only a few pots have a plastic mounting shaft for a knob. The plastic shaft means that metal knobs won’t become parts of the electric circuit and it’s a good safety precaution. However, a plastic shaft can cause static electric cracking sounds.

Shielding a pot is difficult. Some companies make covers for pots with an exit hole for the side for a coaxial wire. This helps to make a quiet, well grounded circuit. See this book’s section on shielding for more information regarding the shielding of pots.

The pots used for guitars are ¼ to 2 watt pots. Because the current of a guitar’s pickups is normally under ¼ watt, low wattage pots are more than adequate. Most small pots use inexpensive carbon resistance paths. But quality pots use conductive plastic or cermet paths for longer life and smooth operation.

TOGGLE CONTROL

The tone control is also a pot, but it has something extra – a capacitor. The following should help you understand how it works. If you connect a live hot lead wire to a ground wire, silence will result. Now, if you put a capacitor between the two wires, an interesting
HARDWARE COMPONENTS

Fig. 13. The function of a tone control.

thing happens; the trebles have disappeared but the rest of the guitar's output has not. This is because trebles find it much easier to pass through the capacitor than other frequencies. If you had an on-off switch with a live lead going to a capacitor and ground, you could have two sounds: Full tone (when the switch is off) and no tone (when the switch is on). To achieve more variations, you can regulate the amount of treble that is taken away. If you use a pot instead of the switch, you can vary the amount of treble sent to ground through the capacitor. This is the tone control most guitars have. It is referred to as a passive control because it doesn't add anything, it can only subtract. This passive tone control just reduces treble and its specific title is treble bleed tone control.

There is another possible simple tone control, it's old and isn't used very much, it's called the treble pass tone control and it's found on Howard Robert's style guitars made by Ibanez. It is often called a bass tone control because its capacitor only allows trebles to
detour the pot. Bass tones can't get through a capacitor, they have to go through the pot. In effect, the pot increases or decreases bass by producing an effect that equals the opposite of the treble bleed control.

Capacitors

Capacitors are used as a part of tone controls. They are simple, inexpensive, trouble-free devices that range in cost from 2¢ a piece and up. Only great amounts of heat or current can cause a capacitor to fail.

Circuits measure weight, farads, measure capacitance. Capacitors are rated at a specific farad capacitance and a specific level of voltage. The voltage figure tells you how many volts the capacitor could withstand. Guitars are very low voltage, and therefore, very low voltage capacitors can be used. The higher the voltage rating, the bigger the capacitor and this is another reason for using low value (small) capacitors. When working with guitars, you should never need anything bigger than a 100 volt capacitor.

The least expensive capacitors are ceramic discs whereas the most expensive ones are made from mylar and sealed in a resin dip.

Fig. 14D. Two round ceramic capacitors, and two square mylar dip capacitors.

Circuits used in most guitar circuits range in value from .001 microfarad to 0.01 microfarads. A microfarad is one millionth of a farad. A .001 mL capacitor will pass only very high frequencies and some upper mid-range frequencies. The value of a capacitor determines the amount of treble cut of a common tone control. A high value capacitor, e.g., .05, can produce a bassier tone, i.e., less treble, than a lower value, e.g., .02. Generally, single coil pickups can use a .02 micro-farad capacitor, dual coil pickups use .05 ones and basses use .05 or even a .08. However, Fender has mainly used .01 to .05 caps, and Gibson uses a lot of .02 caps. Many people experiment with using capacitors of different values to achieve different sounds. This experimentation can’t harm a guitar.

KNOWNS

A good quality knob is solidly made, and it fits precisely and securely on a pot shaft. It turns totally concentrically. Metal knobs look classy, but they are electrically conductive. However, plastic knobs will sometimes crack or break. Some knobs are made with an allen keyed set-screw to affix it to a shaft. It’s a good idea to make a flat spot on a shaft to receive this set-screw. Other knobs have internal ridges for being press mounted on knurled (fluted) pot shafts.

Fig. M2. Knobs for knurled shafts, and knobs for smooth shafts.

Fig. M3. New style Tele switch knob (left) and an old style Tele switch knob (right).

The '54 Strats had pearl-white knobs, '55 models had bright white bakelite-type knobs, and newer Strat have simple soft white plastic ones.

TYPES OF SWITCHES

Switch Functions

The most basic switch is a lever switch which can open and close a circuit. The switch connects to a single set of wires, and it is called a single pole (SP) switch. Because the switch has two positions, one and two, it also is called a dual position switch. The technic term for each position is throw, so this simple switch is a double throw or dt switch. The two functions are put together to make the identity of the switch specific - SPDT tells you exactly what a switch is.

If there are two sets of SPDT lugs that have parallel functions, the switch has dualpales and is a DP switch.
HARDWARE COMPONENTS

Fig. 146 Diagram of a single pole, single throw switch.

Fig. 147 Diagram of a single pole, double throw switch.

Fig. 148 SPDT switch.

If there are three possible positions, a switch has triple throws – TT. The pole designation comes first and it is followed by the number of throws.

Fig. 149 Diagram of a double pole, double throw switch.

A pickup splitter control uses a SPDT unit; whereas a series/parallel or phase switch control uses a DPDT switch. If you use three-position toggles with a center position which is off, you could have an on-off switch. With this type of switch, the volume knob doesn’t have to be turned down to obtain silence; this is very convenient when you want to leave the guitar on standby.

The Three Position Toggle
The most common electric guitar switch is the three position toggle which is used on Les Pauls, SGs, and many, many others. It allows three selections: pickup #1, both pickups, or pickup #3. The wires go from the pickups, to the switch, and then to the controls and output. Les Pauls take a tall switch, and thinner bodied guitars, e.g., SGs, take switches formed into a right angle.

Fig. 150 DPDT switch.

The Five Position Lever
This originated as a hot rod replacement item for Strats but now Fender offers it on new Strats. It allows the standard three positions, but it also offers two more; these selections are pickups 1 and 2 together, and pickups 2 and 3 together. These positions are located between positions 1 and 2, and 2 and 3 on a three-way Strat switch.

The Six Position (four pole) Rotary
Rotary switches allow the construction of switching systems too complex for one DPDT (and other similar) switches. Rotary switches are available in many configurations: one-pole twelve-throw, two-pole four-throw, four-pole six-throw, etc. One 4P6T rotary switch can provide as many switching selections as four DPDT switches.
HARDWARE COMPONENTS

These special switches have not been fully utilized by guitar makers because the switches are not well known at this time. Many switches are expensive, one reason for this is that they are made for the strong voltages of household current and guitars don’t need this, but no one makes tiny high-quality low voltage switches. When soldering, switches are not as sensitive to heat as transistors, but you should be careful not to heat one so much that you start to melt the plastic case. It is advisable to buy the switches that have plastic lever covers because this provides a layer of electrical insulation between the metal and you. This is wise because the cases of switches need to be grounded. The best way to wire a ground to a switch is to solder a ground wire to the washer that fits around the switch’s threaded bushing.

JACKS

The standard jack on a high impedance guitar is a chassis-mount 1/4 inch, two connector, female audio jack. Similar jacks come with three connections for stereo. Others have built-in prongs which act as on-off switches, and when a plug is inserted, an electrical connection is completed. These on-off jacks are used to eliminate the need for having to remember to turn off a preamp.

CONNECT HOT/LEAD HERE
THIS CONNECTS TO HOT LEAD LUG
CONNECT GROUND HERE

 Fig. 162 Mono jack.

 Fig. 163 How a cord plugs into a jack.

Unfortunately, most jacks are not shielded, and guitar circuits should be completely shielded to prevent shock. Be careful when handling faulty old jacks, oftentimes the insulation between the elements compresses or breaks which can cause a shorting-out of parts that should not touch. Sometimes a jack will oxidize and short out, but this usually can be repaired by cleaning.

CORDS

The quality of a cord affects the quality of your sound. Hisses, hums, ratches, and crackles can all be yours with a bad cord. Regardless of price, any cord can go bad. What kind of things go bad?

1. Loose connections, causing crackles and on-off sound breaks, or sometimes resulting in no sound at all.
2. Poor shielding, causing hum and hissing.
3. Loose or broken internal wires, caused by bending or stepping on cords. This results in a loss of sound, or it can mean a microphonic sound or crackling.

Therefore, look for the following features in a new cord:

1. 100% braid shield, not a half-way slip-shod wrapping. You may have to unscrew the jacks to check the shield, and no honest music store should deny you this right.
3. Secure attachments in the jacks for connecting wires. The best jacks have screws and solder.
4. Every part should be heavy-duty.

 Fig. 164 Two Mono jacks. The one on the right has an ON/OFF connection.

 Fig. 165 Mono jack with an ON/OFF switch.

 Fig. 166 Shielded jack.

 Strap-jack: This is made by a company that feels there is a need for a super heavy-duty jack that doubles as a strap button. This jack is not shielded, and it’s rather difficult to mount/install, but it should last about 250 years.

 Fig. 167 Jacks, from left to right: A Frap end pin, a Baneby end pin, and a Strapack.

Fig. 168 Cord plug with screw terminals.

CORDLESS

The following information is derived from a personal discussion with John Nady, the founder of Nady systems, and printed material that he wrote.

Think of the exhilaration of playing an electric guitar while jumping, turning, and spinning of being able to walk across a stage or studio floor without having to pay any attention to the usual tangle of cords. Imagine playing in a garden while the signals from your guitar...
are beamed to a recording studio. Playing cordless can give you this freedom.

Cordless units come in two styles. The first consists of a transmitter box and antenna that attaches to a guitar strap or a belt, and then plugs into a guitar; the second type consists of transmitter box and antenna (internal) that is mounted inside a guitar. (The truss-rod could be used as an antenna if it’s electrically isolated from contact with any string ground.)

Near the amp, a receiver is positioned to pick up the signals broadcast by the transmitter. A single receiver is satisfactory for about 95% of all playing situations, but more expensive dual (diversity) receivers give better performance.

Wireless transmission of sound was first achieved around the turn of the century. It wasn’t until recently that the fidelity and range of wireless guitars exceeded that of guitars that use cords. The development of this cordless ideal dictated the need for development in a highly sophisticated miniaturized radio transmission system. A well designed wireless system offers several technical advantages over a cord. Cables are not ideal transmission systems for audio signals. Due to the inherent capacitance, they act as lowpass filters and roll off the highs when used with musical instrument pickups. In fact, they no longer pass true high fidelity at lengths over 5 to 10 feet. At lengths over 20 feet, the sound becomes “muddy”. In addition, cables act like antennae and pick up spurious noises from light dimmers, radio signals, power lines and other external sources. Used with certain combinations of effects pedals or amps, cords often pick up nearby radio stations and CBers.

The most practical benefit of cordless operation of electric instruments is the total elimination of potential electric shock hazards. Such common shocks, caused by improperly grounded amplifiers and/or other equipment malfunctions, have even proved fatal at times (Lois Harvey of Stone the Crows and Keith Relf of the Yardbirds were both electrocuted in this manner). A well-designed wireless system generally has a usable range of about 150 feet minimum under adverse conditions, and up to 1,500 feet line-of-sight. Different applications, of course, require different operational ranges. Due to the speed of sound travel, there is an acoustic delay of about 100 milliseconds at that distance. It is difficult for musicians to keep in time at longer distances.

There are two frequency bands most successfully utilized by today’s professional wireless systems: the commercial FM (88-108 mHz) band, and the VHF business and TV channels bands (150-216 mHz). The wireless system operating in the commercial FM band are tunable so that they can be tuned to blank spots between FM stations. The VHF systems are all fixed frequency and cannot be tuned to open frequencies. For applications such as traveling musicians, live recordings, etc., where clear channel accessibility and freedom from random interference is a must in all locales, a well-designed, frequency stable tunable system is recommended.

Distortion, frequency response, dynamic range and dropouts are the three key subjects when looking at cordless transmitter systems.

1. Distortion: Measuring distortion in any piece of electronic gear can be a numbers game, and wireless systems are no exception. Published specs often quote a figure that represents a best case situation that may not reflect realistic in-field usage. The best new systems improve that performance to about 2 to 6% THD.

2. Dynamic Range: The greatest single breakthrough ever in the performance of wireless systems is the recent dramatic improvement in dynamic range offered by the best of the new units. Signal-to-noise was improved from a previous high of about 65dB to over 100dB. By way of comparison, a commercial FM station only registers about 70dB signal-to-noise through a high quality receiver.

3. While passing through the air from transmitter to receiver, radio waves will generally encounter a maze of reflective and absorptive obstructions. When radio waves bounce off nearby surfaces and meet in space, such that one wave’s crest encounters a reflected wave’s trough, a 180° cancellation occurs. A receiver antenna located at that point in space will register no received signal and a radio dropout will result. Although these null spots can occur at any receiver distance from the transmitter, they are fortunately very infrequent up to ½ to ⅔ of the system’s ultimate range at any given location. In “receiver diversity” two separate receivers and two separate antennae are employed to process the single transmitted radio signal. In a well-designed true diversity system, a totally silent comparator circuit continuously monitors the received RF signal strength of both receivers and instantly selects the audio output of the receiver with the stronger signal. In this way, there can be no vector cancellation of the received signals.

Since cordless systems have improved, it seems only a matter of time until many instruments are factory wired for cordless operation or at least come with an empty compartment for placement of a transmitter. Although rock musicians have been the first to enthusiastically welcome cordless transmitters, it would seem likely that more conservative musicians will eventually become “secret” users. What better musical device could bluegrass players have than a transmitter. A whole group could look like they were playing acoustic instruments when in fact, the guitar, banjo, mandolin, and fiddle would all be wired for playing “electric”.

Fig. 170 Nady cordless transmitter equipment.

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Fig. 171 Actual size of a Nady cordless transmitter.

GUITAR ELECTRONICS

Similar to his original designs.

Because of the use of high impedance amps, high impedance pickups became the norm. Until circa 1970 nearly all guitars were high impedance units. The transistor really changed things because the transistor is basically low impedance.

Solid state amps are by nature lower impedance than tube amps. They are admirably suited for use with low impedance pickups and preamps. Nowadays with the use of solid state preamps and other transistor based circuits, solid state power amplifiers are bound to become more popular.

Speakers

Speakers need some comment because they are the last link of the pickup chain. We hear the sound of a pickup and judge it from a speaker. Speakers come in many sizes and designs, and even identical speakers can be as variable as pickups. To evaluate pickups, it’s best to hear them all using the same guitar, amp, and speakers. Small speakers give more crisp, high notes. Large speakers give more solid, low notes. Generally, large magnet structures give more fidelity and more power. Hi-fi speakers can not take the demands placed on them by musical instruments.

AMPS & SPEAKERS

Amps – Solid State & Tube

It is necessary to know some things about amps because you need to match a pickup’s impedance and an amp’s impedance for the best in sound and amplifier operation.

The first amplifiers used vacuum tubes, or to use the Great Britain term – valves. These devices had a high impedance, and for this reason, devices designed to plug into tube amps were also designed to be high impedance.

Leo Fender is largely responsible for the creation and popularity of the guitar amplifier. His early designs for tube amps are still revered, and the Fender company continues to make tube amps which are