The Finer Points of Under-Saddle Pickup Installation

Adapted from an article by

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This article is intended to illuminate the finer points of fitting an under-the-saddle piezo pickup. The positioning of a piezo element on or within an instrument is a challenging installation problem. Necessarily, the pickup is extremely sensitive, and accordingly, its environment must fall within a small envelope to achieve full performance. Problems are not always what they first appear to be, but the mysteries WILL BE REVEALED to the perceptive. I have always been able to resolve balance problems by checking and truing the surfaces that touch the pickup. Only rarely should any corrective saddle "sculpting" (see “Drop-In Installations”) be required if the parts around the pickup are correctly shaped.

The Fishman AG-125 and Martin 332 contain 6 piezo elements. For best performance, each element must be located directly under each string - or in the 12-string, under the center of each pair of strings. Yes, it MAY work if slightly misaligned or differently spaced, but there's nothing like getting them right underneath! Our recommendation is no more than .050" total difference between the outside string to string measurement at the saddle and the spacing of the crystal elements within the pickup.

The Fishman Acoustic Matrix Pickup contains a multi-layer configuration of continuous strips of sensing material. This continuous design allows the Acoustic Matrix to sense the motion of the entire saddle, rather than small sections. The job of aligning the strings with the piezo sensing material is eliminated with the Acoustic Matrix pickup.

Please remember that custom length, string spacing or string number pickups are available from Fishman Transducers. Do not hesitate to order a custom pickup if necessary.

Also please note that the methods and techniques described in this article are intended only for *professional* repairmen and luthiers. Fishman Transducers cannot be held responsible for any damages to your pickup or instrument that may result from improper installation procedures.

Stock Pickups Available without Special Ordering

FORMAT	WIDTH	STRING SPACING	WHL	OVERALL LENGTH
THINLINE 332	3/32”	2.125”	.234”	2.625”
		2.3125”	.183”	2.725”
		2.375”	.234”	2.825”
4-STRING		2.125	.234”	2.625”
BACKPACKER		2.190”	.100”	2.500”
BACKPACKER CLASSICAL		2.4375”	.150”	2.825”
AG-125	1/8”	2.125”	.234”	2.625”
		2.155”	.234”	2.625”
		2.00”	.234”	2.500”
AGX-125		2.3125”	.234”	2.725”
B-30 4-STRING		2.0625”	.234”	2.500”
CUATRO		55mm	.234”	2.725”
4-STRING		2.1875”	.234”	2.625”
12-STRING		2.260”	.234”	2.725”
		2.200”	.234”	2.625”
THINLINE GOLD +	3/32”	2.00” - 2.50”	.100”	2.725”
ACOUSTIC MATRIX	1/8” & 3/32”	2.00” - 2.50”	.100”	2.650”
LOWDEN SPLIT		2.00” - 2.50”	.100”	1.750” + .875”

FISHMAN® Acoustic Power

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WIRE HOLE LOCATION

The wire hole must be in the correct place, as per the pickup instructions, drilled 3/32" (,093"), and perpendicular to the bottom of the slot. The wire hole must also be centered in the slot width.

Failure to precisely locate the wire hole may cause balance problems and in worse cases, electrical failure due to a pickup deformed or pinched by saddle pressure.

PICKUP INSTALLATION

OBJECTIVES:

1. Position the pickup under the strings so that it is uniformly loaded in compression between the saddle and the bottom of the saddle slot.
2. Interfere as little as possible with or improve the unamplified sound of the guitar.

METHODS:

(in ascending order of precision, control and complexity)

I - DROP IN INSTALLATIONS

Some guitars will accept a pickup "as is". The pickup wire hole is located and drilled, the pickup installed, the signal and shield wires temporarily "twisted" up to a cord, and the saddle reduced in height as specified in the installation instructions. Re-string and test for balanced output. To avoid unnecessary resoldering and heartbreak, always verify correct operation of the pickup by temporarily hooking up to a test cord.

String balance problems with a drop in installations can often be corrected by "sculpting" the underside of the saddle, equalizing the pressure on the pickup. By sculpting, I mean the adjustment of the saddle bottom to form under string tension, a surface parallel to the slot bottom. This is done to even out the pressure on the piezo elements. See the trouble shooting section for detailed instructions.

Dropping in a pickup is generally successful only on newer instruments where:

1. The saddle slot is not distorted into a long "D" shape (Fig. 1) by an overly tall or loose saddle.

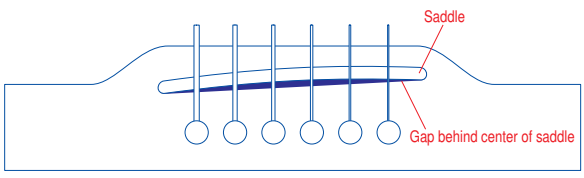


Figure 1 - LONG D-SHAPED SLOT

2. The slot has enough depth to safely reduce the saddle height and maintain proper and desirable relationships between the bridge and saddle (see Mechanical Factors Affecting Pickup Performance).
3. The slot has not been deepened by hand or otherwise chewed up -the bottom of the slot must present a smooth and flat or nearly flat surface.
4. The bridge and top around the bridge are essentially the same shape as when manufactured. Guitars with big "belly-up" will probably need more "sculpting" of the saddle than is easily done.

If all is well, untwist the test wire and solder up as usual. Sometimes the saddle bottom will need to reshaped or "sculpted" one or more times before it successfully squeezes the pickup evenly. This method does not always produce good results, but if the guitar fulfills criteria 1-4, the chances are very good that it can.

The advantage of this is, of course, speed. No major machining is done, and fitting the saddle for good response is within the abilities of any "set-up-capable" repairman.

The disadvantages can be great, also.

1. To lower action from the bottom of a sculpted saddle, the surface needs to be re-shaped. Ugh.
2. We all know that no instrument fulfills criteria 1-4 except the Holy (herringbone) Grail and the box you just built.
3. No chance to correct intonation or saddle tilt. So for many guitars we move to Methods II and III.

II - MACHINING A SLOT

General points to remember:

1. Do not deepen the slot more than necessary - the pickup will sound better the closer it is to the strings, and the bridge will retain its strength in the area of the slot.
2. Check for intonation before routing. Ideally, set the action and restring first to determine if the slot needs to be moved. If so, patch the slot, smooth off the bridge top and lay a piece of some hard material on the top of the now slotless bridge. String up and tap the test saddle around to locate the proper saddle placement. (Fig. 2)

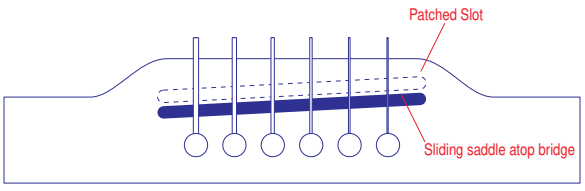


Figure 2 - FINDING INTONATION

The test saddle can be moved around while strung up at correct action height to empirically locate exact spot for new saddle.

3. Under string tension, lay a straightedge across the top behind the bridge. Measure the "belly up" of the top at the edges. This measurement will allow you to reproduce the efforts of string tension by placing a padded screw jack (Fig. 3) inside the instrument under the bridge plate and jacking the top up to this measurement. This step will help to ensure a flat bottomed slot when the guitar is strung up, as well as supporting the top and reducing flutter and excitement (yours and the guitar's) during machining.

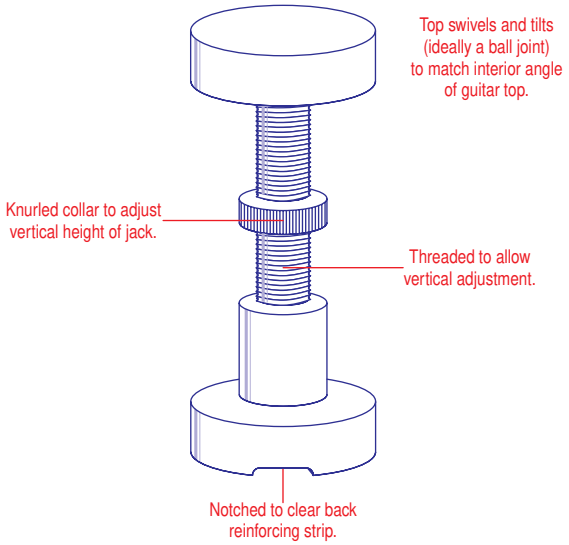


Figure 3 - JACK-Internal jack used to prevent movement of top during critical routing of saddle slot prior to pickup installation.

4. No end mill or router bit is capable of cutting a slot width identical to its diameter. All rotary cutters will shake, bounce on their own chips, etc. and produce a slightly wider slot. One way to beat this is to send a set of bits to your local cutter grinding shop. For a couple of dollars they will reduce the diameter of your standard 1/8" and 3/32" cutters by about .010". These reduced cutters can be used first and followed by full size bits to kiss off the final few thousandths, resulting in a beautiful "wall" surface that will be very close to being "on size". In lieu of a reduced cutter, I like to use a 7/64" (.109") two flute spiral end mill.

5. Single flute bits will perform best in a router. There's lots of chip clearance, lots of positive rake to cut cleanly, and less tendency to bounce around in the slot full of chips.

6. Speaking of chips, the best cut will be had by directing compressed air right at the bit to keep the slot clear and the but cutting freely.

7. We recommend Ekstrom-Carlson bits, available from your local E-C distributor (call 815-968-0961).

3/32" x 9/32" long x 1/4" shank PART # 011-0309
1/8" X 3/8" long x 1/4" shank PART # 011-0412

(Also their two flute downcutting bits are unsurpassed for general {chipping free} routing chores in the shop.)

8. 5 - 8 DEGREES: What about these few degrees? Well, we think you should tilt the saddle back by this amount whenever you cut a saddle slot. Here's why:

a. The backwards tilting saddle will be much better at resisting the tendency of the center strings to bow to the saddle forward and create a long "D" shaped saddle slot and its accompanying space between the back of the saddle and the back of the slot.

b. The pickup will "see" more downbearing force and will sound better.

c. As a result of better force distribution between the saddle and bridge, the bridge will remain more stable, resist distortion and bending, and sound more solid. (Remember Objective II?)

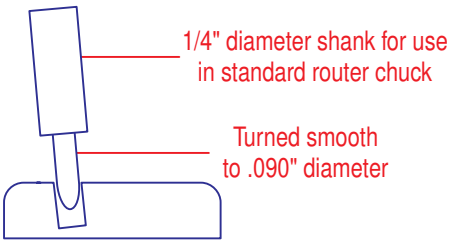
Even though it's more trouble and it ain't historic, etc., we're convinced that it does really improve the pickup installation and often, the acoustic response. Further, it's not so much angle that it looks objectionable.

As a bonus, this technique often helps us move the string take off point a little further back on the bridge, when needed to help correct "folding-up-sharp" intonation.

a - ROUTING A SLOT

You will need a small plunge router to do the job. Make a base for the router with a 5-8° angle to achieve an angled slot. Make a routing jig to fit on top of the guitar. Cover the bottom of the jig with a cork or rubber gasket. The jig bottom should clamp to the guitar's edges only, and not tend to squeeze out the belly shape in the top, thus accommodate the aforementioned screw jack. The guide for the router base must fit precisely to avoid slop in the cut. Make adjustable endstops for to the length of the cut.

A nice way to locate the existing slot is with an undersize pin chucked in the router. Dropped in the slot, the pin is a quick set up tool for slot angle and ends. (Fig. 4)



FIQURE 4 - PIN LOCATES SLOT WITHOUT RISK OF DAMAGE.

b - MILLING A SLOT

Now here's the part I like. Just walk over to your milling machine and put the acoustic guitar jig in the vise.

"Say what?"

Oh. Hmmm. Well, can I suggest that you CONSIDER buying one? There's no end to the utility of a milling machine in any small shop, especially a repair/builder's shop.

Even the smallest vertical milling machine will bring your shop's capabilities to a whole new level. Anything that's supposed to be drilled, bored, pocketed, trued, parallel, flat, square, slotted, threaded, round, tapered, grooved, funked up, chamfered, sliced, diced, etc., etc. will stand a good chance of getting that way if you can affix it to the table of your vertical mill.

I'm well past the point of running my shop or doing my work without one and I consider it the most important and versatile tool in my shop.

For this job a sturdy, thick work board with a strong tab for gripping in the milling vise will serve to support and position the guitar. Clamp up and indicate the slot true with the machine travel, insert the bridge jack and tension it, squirt some air at the cutter and make a pretty slot. The great advantages of the milling machine over the router include:

1. Absolute confidence in control of the cut.
2. The ability to widen, deepen or lengthen the slot in tiny increments, as needed.
3. Perfect visibility.
4. Control over the angle of the saddle slot (5-8 degrees) as desired by simply tilting the jig in the vice.
5. Great setup for drilling a clean and accurately positioned wire hole.

SADDLES

Another great advantage of the mill is the beautiful saddle blanks it can generate. Whatever your choice of saddle material - organic or plastics, the blank will come out square, straight and parallel - and to size.

Actually, I like to leave just a couple thousandths for sanding with 500 grit. This makes possible a really sweet fit between slot and saddle so that the saddle can just slip in and out without friction, but not looser. For example, the saddle should slide into the slot easily, but not fall out of the slot when overturned. This transfers energy from string to bridge optimally. Even if you make saddles by hand or on a belt sander you should try for this kind of fit.

Use a micrometer to check thickness all over the blank and really get it parallel and square. If you err on the tight side and the pickup response is weak or muffled, it's a quick job to sand another thousandth off. Too loose, and it's junk. Be sure to check for flatness and squareness on the bottom of the saddle again before installing it. There is often a distortion when parting the blank off a larger piece or removing thickness. Also, LIGHTLY chamfer the bottom corners all around.

TROUBLESHOOTING

1. WEAK STRING OR STRINGS

Try pushing down on the saddle over the weak strings. Sometimes it just needs a little persuasion when first strung up. (Tell your customer this.) If this doesn't help, and repeated pushing yields repeated groans, crackles, etc. (amp on please) then you can be sure that the pickup is not getting the even squeeze it needs to get. Remove the saddle, check the bottom for flatness and squareness, and check for debris in the slot. Next, sculpt the saddle to equalize pressure on the pickup. This will only rarely be necessary if you've done a careful job of jacking the guitar top.

By sculpting, I mean the adjustment of the saddle bottom to form, under string tension, a surface parallel to the slot bottom. This is done to even out the pressure on the piezo elements. For example, if the outside strings are low in output,scrape the saddle hollow to increase pressure on the outside elements. If you've recut the slot with a bridge jack, as suggested, and you encounter this problem, it probably means that the jack should have been adjusted taller.

You may also try placing a .020" cedar shim under the entire length of the pickup. A cedar shim often will have just enough "give" to correct string balance problems that result from minute differences between the saddle and the bridge slot.

2. PIEZO-DECEPTION

Sometimes a string's "low" output can be relative to an unnaturally "hot" adjacent string which is too lightly loaded. This can be hard to troubleshoot until you know that an element's output when properly loaded is LESS than its output when loaded too lightly.

Demonstrate this for yourself by loosening and then tightening all the strings while the guitar is plugged in. You will notice an increase in output and a change in tone.

With a ceramic pickup, you can usually hear some output from a string even if the element below it is totally unloaded, due to "leakage" from adjacent elements. In this case, applying thumb pressure over the problem string will usually activate that element and make those crunch and crackle noises. If so, it's time to check and correct straightness, squareness and fit again.

A common example of this that can be very puzzling can occur in guitars with lots of "belly up". In the event that the bridge slot is being crowned up by bridge tension, the outer strings might EITHER be too hot or too low depending on whether they are loaded, respectively, too lightly or not at all.

3. 60 CYCLE HUM

If this is a problem and is accompanied by low output, it is almost certain to be the result of very little pressure on the pickup, yielding a poor signal to noise ratio. One common cause is a saddle that's binding in the slot. Be sure not to get too carried away when easing the fit between saddle and slot. Try for the closest slip fit that you can achieve.

4. MECHANICAL FACTORS AFFECTING PICKUP PERFORMANCE

a. BREAK ANGLE

There must be an adequate amount of downbearing pressure on the pickup in for it to perform optimally. The pickup will "see" an acceptable amount of downbearing pressure when there is a 20° (minimum) break angle across the saddle (Figure 5). A pickup in a Guitar with less than a 20° break angle will often have string balance problems as well as poor tone. For such instruments, an adequate break angle can be realized by "ramping" the string slots or (in extreme cases) raising the saddle height and resetting the neck angle.

b. THE 50/50 RULE

For adequate coupling between string, saddle and pickup, we recommend that the saddle slot depth (with pickup installed) should equal no more than 50% of the total height of the saddle.

ADJUSTING FOR A TOO DEEP SADDLE SLOT

If the slot (with pickup installed) measures more than 50% of the total saddle height, the pickup performance will often suffer. To correct for a too deep slot, add a shim under the pickup. Determine the proper thickness of the shim by subtracting 1/2 of the total saddle height from the slot depth (with pickup installed). Then, remove an equal amount of material from the bottom of the saddle.

EXCEPTION: Pickups in guitars with a very steep string break angle (25° or more), will generally perform well, even if the saddle slot depth measures more than 50% of the total saddle height.

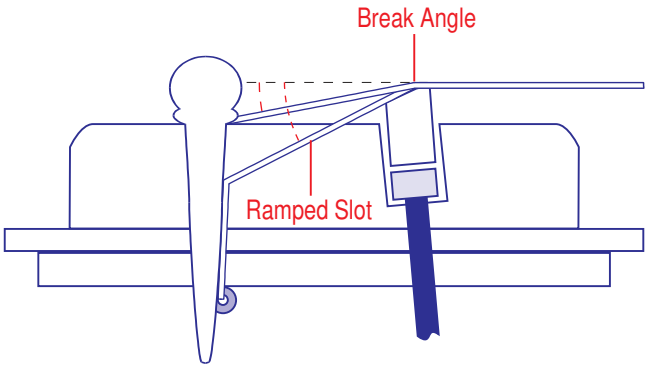


Figure 5 - DOWNBEARING

PICKUP AND SLOT WIDTHS

A 3/32" pickup should be used only in slots under 1/8" wide. Avoid having the pickup angle across a wide bottomed slot. If the slot is over .110" or so, it's best to recut for a .125" saddle and wider format pickup. This is often convenient when correcting too-sharp intonation by moving the back wall of the slot towards the back of the bridge, as a substantial improvement can be made in saddle placement, without patching and recutting the original 3/32" slot.

CUSTOM PICKUP LENGTHS

Pickups can be custom made to fit all instruments with saddles. Some examples are: seven, eight, ten, etc. strings, very wide or narrow six string spacings, "split" or multi-piece saddles and custom colors. The practical limit to pickup length is 3" for ceramic pickups and 4" for co-polymer pickups. For longer applications, two or more pickups are necessary, to be wired in parallel. Also bear in mind for custom orders that the usual overall length of a pickup is found by adding .430" to the overall string spacing, although this can be reduced, upon special request, to as little as spacing + .350". In this case, and for the 2.3125" and 2.4375" spacing pickups, the wire center to the first element center distance is reduced from the normal .234" to .183" and sometimes .130". If you are installing one of these special pickups, make sure that you know which spacing you have.