From:	**Andrew C.**
Date:	☑ 1/17/2005 10:33 AM
Subject:	**Dummy coil experiments - Moocow?**

Hi Guys,

I have been playing around with dummy coils and I can say they work, and the effect on tone isn't so bad, but I just hooked one up so that is can be dialled in via the second tone control (thanks to Steve Aloha wiring help!), and the results are great, but there is still a little hum that occurs with guitar re-orientation. And it doesn't quite pass the computer monitor test yet.

Maybe electronics gurus (did I say Moocow?) could chew over this...

My coils are very standard 5mm alnico slugs with heavy formvar wire, wound to between 7500 and 8200 turn depending on the customer. The dummy coil I used is just a cheap strat coil with the ceramic magnet taken off the bottom and the slugs pulled out. I want to make a dummy that will cancel as much as hum as possible. Which of the following will be the best solution and way?

All coils have the same dimensions and turns as the real coils.

1. A coil with nylon poles
2. A coil with brass poles
3. A coil with unmagnetised Alnico poles

1 seems right, but 3 will mimic the EMI of the original pickup, no? - Three maybe a trade-off

I don't know

Andrew C•

From:	**Joe Gwinn** @
Date:	☑ 1/18/2005 2:48 AM
Subject:	**Re: Dummy coil experiments - Moocow?**

On 1/17/2005 10:33 AM, Andrew C. said:

> *I have been playing around with dummy coils and I can say they work, and the effect on tone isn't so bad, but I just hooked one up so that is can be dialled in via the second tone control (thanks to Steve Aloha wiring help!), and the results are great, but there is still a little hum that*

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1 seems right, but 3 will mimic the EMI of the original pickup, no? - Three maybe a trade-off.

In the Silence of the Moocow, I'll venture a question: Have you tried using a copy of the pickup coil (but with no magnets) as the dummy coil? In other words, wind two coils, buit put magnets in only one of them.

At power frequencies, eddy currents aren't such a problem, so nylon poles (or just air) should be OK. Unmagnetised alnico is the most pedantically correct, but may not be necessary. Time for some more experiments.

From:	**Dr. Strangelove**
Date:	☑ 1/18/2005 3:25 AM
Subject:	**Re: Dummy coil experiments - Moocow?**

Joe wrote:

Unmagnetised alnico is the most pedantically correct, but may not be necessary. Time for some more experiments.

A thought:

Why not tweak the dummy coil inductance by putting in more or fewer steel poles? If this is on track, you might roll off the treble response with a steel slug or three.

Rationale:

The inductance of the coil is determined by the number of the winds and the core permeability. A magnetic core (i.e., pole pieces) has permeability between that of air and steel.

Higher permeability = more inductance = less treble.

Dimarzio tuned some of their pickup coils with small ferrite slugs between the poles or screws, notably their Virtual Vintage models.

-drh
--

From:	**Joe Gwinn** @
Date:	☑ 1/18/2005 1:41 PM
Subject:	**Re: Dummy coil experiments - Moocow?**

On 1/18/2005 3:25 AM, Dr. Strangelove said:

> *Why not tweak the dummy coil inductance by putting in more or fewer steel poles? If this is on track, you might roll off the treble response with a steel slug or three.*
>
> *Rationale:*
>
> *The inductance of the coil is determined by the number of the winds and the core permeability. A magnetic core (i.e., pole pieces) has permeability between that of air and steel.*
>
> *Higher permeability = more inductance = less treble.*

Yes, but what Andrew is trying to do is to reduce hum. The rationale for hum cancellation is to make the two coils respond the same, so their hum outputs will cancel. Inductance and treble response are unrelated issues.

Going back to my piece on how humbuckers work, recall the two identical circular one-turn coils. What I didn't mention is that what's necessary is that the areas of the two coils be equal.

The area of a circular coil is the area of the circular disk whose edge is the coil wire, so if the radius of the coil is r, then the area is Pi r^2, as we all learned in high school.

If the coils are the same size and shape, the areas will be the same, but it's the area that's fundamental, not the exact shape. To take an extreme example, take one of the circular coils and crush it into a flat loop of almost zero area. Now, almost no hum voltage is induced, unlike the uncrushed coil, so hum cancellation fails. By contrast, if we partly crush both coils to the same shape, cancellation still works, because the areas are the same. The coils need not be circular, but must have the same area.

In a big thick coil with 10,000 turns, the easiest way to make the various areas equal is simply to use two identical coils.

Even with identical coils, cancellation will be degraded if the hum field is non-uniform (such as from a nearby power transformer), because the two coils will then see different strengths of hum field. The remedy is to put the coils as close to one another as possible without also cancelling the music.

From:	**Andrew C.**
Date:	☑ 1/18/2005 3:20 PM
Subject:	**Re: Dummy coil experiments - Moocow?**

It would be great if I could design the dummy coil in a way that it helps the treble! But in the absence of that it looks like we can decide that the SHAPE of the coil should be the same, but the poles might be better made with any of the materials - only testing will tell. I'll let you know how it goes.

Now where did I put those nylon rods? Anyone?

While I am at it I am also going to overwind the dummy and see if I can can "overcancel" the hum - might work, might not.

BTW the original dummy system went well at band practice last night - (I am the rhythm guitarist in "The Believers". I have always been in the "strats hum who cares" camp, but this really was an "ear-opener". This is actually a client's guitar (a Highway Strat), and I don't normally sneak out with other people's guitar when the leave them with me, but I could resist playing with another guitarists, both of whom would be using the same rig - passive strat into seperate JCM2000 heads.

I kept the noiseless tone pot on full all night, and hardly noticed a difference in tone, although I think my guitar had a little less presence at time (perhaps a drop off in the mid-high EQ range). But it was amazingly quiter. The lead guitarist also plays a strat and I suddenly was hyper-aware of the terrible noise his guitar was making, the hum seemed enormous. On consideration, I would say that we are almost conditioned from Day 1 playing music that rehearsals and gigs should sound like hum. When the singer says "cut", the noise never really stops, it just gets a little lower. Imaging the lowered stress levels that might have occured if there was piece and quite during rehearsal...a few great bands might even still be with us!

I am officially going on record as saying "I haven't heard a great noiseless pickup yet, but being noiseless is a very, very desirable thing."

I just popped my noiseless cherry I think.

Andrew C

From:	**moocow**
Date:	☑ 1/18/2005 7:59 PM
Subject:	**Re: Dummy coil experiments - Moocow?**

Hey, I wasn't silent, I was doing some measurements and analysis! Anyway, here's what I wrote last night. I didn't see the bit about increasing treble response but maybe I can work on that and see what I can come up with. The description of the dummy coil sound matches up with the simulations I did of the pickup's frequency response when the dummy coil is added. Also, thanks Joe, for discussing circular coils!

I would recommend the bobbin with no poles. The dummy coil goes in series with the pickup, so its impedance is added to that of the pickup. To minimize the effect on the overall sound of the pickup, this means the dummy coil's own impedance should be as low as possible. The dummy 'pickup' (bobbin with Alnico slugs) is the worst choice because it has the highest impedance of the three possibilities. As an experiment, I removed the magnets from a Jackson Strat pickup I had lying around. With the magnets in place, it measured 3.4H and with the Alnico magnets removed from the plastic bobbin, the inductance dropped to 1.8H. I also did some calculations and it appears the extra 1.8H of inductance of the dummy coil would cause some slightly audible effects in the pickup's frequency response. However, the dummy pickup's 3.4H would affect the frequency response even more, enough to be noticeable.

A few weeks ago, I started some calculations for a dummy coil wound on a circular form. The idea is to use a coil that has a larger area than a pickup so it will introduce the same amount of noise with fewer turns. Since inductance drops with the square of the number of turns, the fewer turns I need, the lower the inductance of the dummy coil. At this point, my calculations are very rough but they indicate a 3" coil of less than 500 turns will cancel the noise of a Stratocaster pickup. The calculated inductance is far less than 0.1H so it should have almost no measurable effect on the frequency response at all. But calculations are only good to a certain point. At best, they tell me whether or not further experiments are justified. I would need to wind some dummy coils and measure their impedance as well as their hum-reducing properties to know for sure.

Also, I was doing some reading about hum-canceling in general and it turns out that the hum-bucking coil idea has been around for a very long time. One description in my 1941 copy of Radiotron Designer's Handbook mentioned that the dummy coil won't necessarily pick up the same harmonics as the pickup. The noise we are trying to cancel is not a smooth sinusoidal signal. For example, the power transformer of an amplifier draws current in pulses at 120Hz. Each pulse is very large and narrow, so it contains a large amount of higher frequency harmonics. Our guitar pickup is going to detect a somewhat different spectrum than a dummy coil that doesn't have Alnico polepieces, so the noise cancellation will not be complete. However, I believe this is an acceptable engineering trade-off. A single dummy coil can't cancel the hum from different pickups unless each pickup and coil is wound exactly the same. We already know that it is traditional for bridge pickups to be wound with more turns so we can never get complete cancellation with a dummy coil system. It is better to settle for what we can get and minimize frequency response changes by using an air-core dummy coil than to aim for complete cancellation (which we can't get anyway) by using Alnico slugs and changing the frequency response in an audible fashion.

From:	**Joe Gwinn** @
Date:	☑ 1/19/2005 2:44 AM
Subject:	**Re: Dummy coil experiments - Moocow?**

On 1/18/2005 7:59 PM, moocow said:

> *Hey, I wasn't silent, I was doing some measurements and analysis! Anyway, here's what I wrote last night. I didn't see the bit about increasing treble response but maybe I can work on that and see what I can come up with. The description of the dummy coil sound matches up with the simulations I did of the pickup's frequency response when the dummy coil is added. Also, thanks Joe, for discussing circular coils!*

Ahh, mumbling into one's beard doesn't count. Nor does conversing with the hardware. Especially if it answers.

> *I would recommend the bobbin with no poles. The dummy coil goes in series with the pickup, so its impedance is added to that of the pickup. To minimize the effect on the overall sound of the pickup, this means the dummy coil's own impedance should be as low as possible. The dummy 'pickup' (bobbin with Alnico slugs) is the worst choice because it has the highest impedance of the three possibilities. As an experiment, I removed the magnets from a Jackson Strat pickup I had laying around. With the magnets in place, it measured 3.4H and with the Alnico magnets removed from the plastic bobbin, the inductance dropped to 1.8H. I also did some calculations and it appears the extra 1.8H of inductance of the dummy coil would cause some slightly audible effects in the pickup's frequency response. However, the*

> *dummy pickup's 3.4H would affect the frequency response even more, enough to be noticeable.*

I'm surprised that removing alnico poles cut the inductance in half; I would have expected the inductance to rise a bit, as the eddy current shielding effects are eliminated, because the incremental permeability of alnico is something like 1.03, the moral equivalent of air. How was the inductance measured? Likewise, AC resistance?

> *A few weeks ago, I started some calculations for a dummy coil wound on a circular form. The idea is to use a coil that has a larger area than a pickup so it will introduce the same amount of noise with fewer turns. Since inductance drops with the square of the number of turns, the fewer turns I need, the lower the inductance of the dummy coil. At this point, my calculations are very rough but they indicate a 3" coil of less than 500 turns will cancel the noise of a Stratocaster pickup. The calculated inductance is far less than 0.1H so it should have almost no measurable effect on the frequency response at all. But calculations are only good to a certain point. At best, they tell me whether or not further experiments are justified. I would need to wind some dummy coils and measure their impedance as well as their hum-reducing properties to know for sure.*

I see no reason why this won't work too. Pickup voltage varies directly with the product of the number of turns and the coil area, while inductance varies as the product of area and the square of the number of turns, so making the coil bigger and reducing the turns count, with output voltage held constant, will reduce inductance and resistance. Self-capacitance may also be reduced. Together, these will raise the resonant frequency and increase the Q, moving the effects of dummy-coil resonance away from the frequency range important to guitars.

However, unless the calculations are pretty detailed, achieving hum cancellation will require empirical adjustment of the number of turns on the dummy coil because not all turns in the pickup have the same area, and the poles/slugs will affect the pickup coils more than the dummy coils.

A good approximation to the "detailed calculations" is to mathematically divide the pickup coil into about five nested shells each having one fifth of the total turns count, compute the area-turnscount product for each, and sum the five products. This sum should equal the area-turnscount product of the dummy coil. If necessary, the dummy coil can also be divided into some nested shells, and the two sums set equal. (This approach assumes that the hum field is uniform, the usual case.)

How many turns were there in the simulated pickup? The area of a 3-inch circle is 7.07 sqin, while the average turn on a pickup has about 1 sqin of area, for a 7:1 ratio, which would balance a 7*500= 3,500-turn pickup coil; this seems a bit low for a pickup.

There are a number of pickup designs where the active coil and dummy coil are concentric, which will handle non-uniform fields the best. Nearby is good too, and may be the best one can do if one dummy coil is supposed to cover for two different pickups, at neck and bridge.

From:	**moocow**
Date:	☑ 1/19/2005 3:51 PM
Subject:	**Re: Dummy coil experiments - Moocow?**

Joe, thanks for the feedback. I looked at my spreadsheet calculations for the circular dummy coil and it had an obvious error that made the turns count come out too low. I fixed it (I think) and the turns count came up to 630, but I'm getting an average pickup coil area of .74 square inches, not 1.0. The spreadsheet equations are pretty rough at this point and I need to go through them again, but so far they tell me that a circular dummy coil will have far fewer turns than a pickup. This means the inductance will be much, much lower and the resistance will be lower as well. If the total impedance of the dummy coil is low enough, its overall effect on frequency response might even be within measurement error (>2%), so it won't have an audible effect on the 'presence' of the pickup.

The method I'm using to measure inductance is based on a single measurement of the pickup when placed in a simple RL circuit:

http://home.comcast.net/~bcbarrera/files/pickup/Inductance_Measurement.gif

Of course, I put the equations into an Excel spreadsheet so it really isn't too difficult to get the inductance calculation once I have the voltage measurment. As a check, I used a PSpice simulation to make sure I didn't make a mistake with my equations. Also, I placed known capacitances in parallel with the pickup and measured the resonant frequency. I did not account for AC resistance but it turns out that AC resistance does not affect the resonant frequency, but it does affect the size and width of the resonant peak itself (Q). The PSpice simulations I run don't include AC resistance so they don't match up exactly with the actual measured pickup response. But the simulations do accurately predict the location of the resonant peak. The simulated peaks are taller and narrower than they are in reality.

I think is it possible for the effects of AC resistance to throw off my inductance measurements, but it doesn't appear to be happening. Perhaps the test frequency I'm using is low enough to keep the eddy currents low. Also, I developed this method by using a Stratocaster pickup, which does not have a metal baseplate or metal cover. I was really surprised by the AC resistance values that were measured on the covered humbucker, so maybe this method wouldn't work as well with a P-90 or covered humbucker. I didn't try to measure resonant frequency with different capacitors on those pickups but maybe I should.

Joe, it would be great if you could repeat my inductance measurements with a de-slugged Stratocaster pickup. I really think the loss of inductance is real because I've seen another spec that gave a permeability of 4 for a certain type of Alnico. There were some other types of Alnico with lower permeability so perhaps this is another clue as to why different types of Alnico sound different. Now that the pickup bobbin is empty, I can machine some steel slugs and see how they affect the inductance. I don't know the inductance will be, but based on my measurements of other steel-pole Stratocaster pickups, I think it will be something like 5H. Time to fire up the lathe!

START NEW THREAD	REPLY	PREVIOUS	LIST

From:	**Joe Gwinn** @
Date:	☑ 1/20/2005 3:59 PM
Subject:	**Re: Dummy coil experiments - Moocow?**

On 1/19/2005 3:51 PM, moocow said:

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Ahh. Now it makes more sense. (7.07/0.74)(630)= 6,018 turns, which is plausible.

> *The spreadsheet equations are pretty rough at this point and I need to go through them again, but so far they tell me that a circular dummy coil will have far fewer turns than a pickup. This means the inductance will be much, much lower and the resistance will be lower as well. If the total impedance of the dummy coil is low enough, its overall effect on frequency response might even be within measurement error (>2%), so it won't have an audible effect on the 'presence' of the pickup.*

This should work. According to the qualitative scaling law derived in my prior post, bigger is better for the dummy coil. How big can the dummy be and still fit into the routed cavity?

> *The method I'm using to measure inductance is based on a single measurement of the pickup when placed in a simple RL circuit:*
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> *http://home.comcast.net/~bcbarrera/files/pickup/Inductance_Measurement.gif*

Of course, I put the equations into an Excel spreadsheet so it really isn't too difficult to get the inductance calculation once I have the voltage measurement. As a check, I used a PSpice simulation to make sure I didn't make a mistake with my equations. Also, I placed known capacitances in parallel with the pickup and measured the resonant frequency.

This sounds like a lot of work. Perhaps it's time for an EXTECH LCR meter?

Alternately, you can build a Maxwell-Wein bridge, if your DMM measures capacitance and your oscillator has low enough distortion. Given those, all that's neede is a handful of film capacitors and resistors, and some potentiometers. And a calculator.

I did not account for AC resistance but it turns out that AC resistance does not affect the resonant frequency, but it does affect the size and width of the resonant peak itself (Q).

The EXTECH and the Maxwell Bridge will both give you the AC resistance.

The PSpice simulations I run don't include AC resistance so they don't match up exactly with the actual measured pickup response. But the simulations do accurately predict the location of the resonant peak. The simulated peaks are taller and narrower than they are in reality.

Agree.

I think is it possible for the effects of AC resistance to throw off my inductance measurements, but it doesn't appear to be happening. Perhaps the test frequency I'm using is low enough to keep the eddy currents low. Also, I developed this method by using a Stratocaster pickup, which does not have a metal baseplate or metal cover. I was really surprised by the AC resistance values that were measured on the covered humbucker, so maybe this method wouldn't work as well with a P-90 or covered humbucker. I didn't try to measure resonant frequency with different capacitors on those pickups but maybe I should.

The AC resistance will throw inductance measurements off, but not grossly off, as the resistance is in quadrature to the inductive reactance. Eddy currents are significant at 1,000 Hz, but far less so at 60 and 120 Hz. Eddy current losses vary with the square root of frequency and directly with the thickness and conductivity of the metal object in which the currents eddy.

> *Joe, it would be great if you could repeat my inductance measurements with a de-slugged Stratocaster pickup. I really think the loss of inductance is real because I've seen another spec that gave a permeability of 4 for a certain type of Alnico. There were some other types of Alnico with lower permeability so perhaps this is another clue as to why different types of Alnico sound different.*

I don't have any pickups that I can disassemble. I need to scare up some sacrifical subjects.

I've never heard of an permanent magnet alloy (or alnico) with such a high permeability as 4; most are within a few percent of unity when magnetized. Can you point me to a source?

Hmm. I wonder what the incremental permeability of a partially magnetized alnico rod is. Fully saturated magnetic materials (hard and soft alike) have an incremental permeability close to unity, but at less than saturation this isn't necessarily so. In soft materials (like mild steel poles), the incremental permeability is easily in the thousands. Permanent magnet materials will still have very low permeabilities, but perhaps not unity. This we can test directly, by testing the same pole in both unmagnetized and magnetized states.

If it turns out that incremental permeability rises as the magnet loses strength, this might explain at least part of why aged pickups sound different. (I would bet that aging of the magnet wire enamel also matters, as well as trapping of moisture.)

> *Now that the pickup bobbin is empty, I can machine some steel slugs and see how they affect the inductance. I don't know the inductance will be, but based on my measurements of other steel-pole Stratocaster pickups, I think it will be something like 5H. Time to fire up the lathe!*

Try copper, brass and stainless steel as well, for the experience? Need to know the exact alloy ID numbers, so we can look up the conductivity (inverse of resistivity), a major determinant of the magnitude of the eddy currents.

While it's possible to measure resistivity of metals (using a Kelvin microhm bridge), it's a bit of trouble to do it with homebrew equipment, as the currents are large and the sample resistances are much much less than an ohm.

From:	**moocow**
Date:	☑ 1/20/2005 6:49 PM
Subject:	**Re: Dummy coil experiments - Moocow?**

Hi Joe,

Here's that link to some magnet data showing 'relative recoil permeability':

http://www.sgmagnets.com/alnico.htm

I don't know which IEC designation is relevant to guitar pickup magnets but there is quite a variety of permeability numbers for Alnico, from a low of 1.7 to a high of 18.0! The same site has data for ceramic and rare-earth magnets and those are shown to have a permeability very close to 1.

I was thinking of mounting the circular dummy coil on the tremolo cover plate of a Stratocaster. The plate itself is about 3" across so I the coil could be mounted to the plate itself instead of being inside of the guitar. Maybe it isn't the best location for picking up noise, but it allows the coil to be large. I also thought of making the coil follow the outline of the trem plate, which would give each turn a huge amount of area. But it seemed a circular coil was a better idea since it maximizes area for a given wire length and DC resistance. Now that it looks like dummy coil inductance is a problem, I'm thinking it is better to minimize turns to minimize the inductance.

Also, I ran the equations for a 2" coil and it gave 1400 turns and about 50mH of inductance. But a 1" coil needs 5500 turns and has almost 1H of inductance, enough to cause audible effects when placed in series with a pickup. The 2" coil might do the trick but certainly, larger is better.

I would like to be able to measure AC impedance and I recently found my Cornell-Dublier decade capacitor box, so assuming the caps haven't drifted out of cal, I can use it in an impedance bridge. I'm using an HP Model 202C signal generator and I'm pretty sure those were designed for use with impedance bridges. For now, I really think it is a good idea to experiment with steel and aluminum slugs in this pickup bobbin. Aluminum will tell me how much impedance change is caused by eddy currents and steel will give me an idea of how much permeability really affects the pickup inductance. I have a feeling that pickups are very, very poorly designed inductors and they don't make full use of the permeability of the core. That's why I only measure 5H for a steel-pole pickup even though the permeability of the core material is many hundreds of times higher than that of Alnico. For steel poles, I thought I'd use music wire from a hobby store. The same music wire is sold everywhere so my experiments can be repeated my anybody. I also have some copper rods I could machine and that would give a known value for resistivity. But first, I'm going to try dropping some steel screws in the bobbins and see how the inductance changes.

From:	**Joe Gwinn** @
Date:	☑ 1/21/2005 3:01 AM
Subject:	**Re: Dummy coil experiments - Moocow?**

On 1/20/2005 6:49 PM, moocow said:

> *Hi Joe,*
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> *Here's that link to some magnet data showing 'relative recoil permeability':*
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Hmm. Now I want to see just how they measure this permeability. And, make tests. But we may be onto something here.

As for translation to IEC designations, perhaps people who have bought from magnet suppliers can suggest some designations.

> *I was thinking of mounting the circular dummy coil on the tremolo cover plate of a Stratocaster. The plate itself is about 3" across so I the coil could be mounted to the plate itself instead of being inside of the guitar. Maybe it isn't the best location for picking up noise, but it allows the coil to be large. I also thought of making the coil follow the outline of the trem plate, which would give each turn a huge amount of area. But it seemed a circular coil was a better idea since it maximizes area for a given wire length and DC resistance. Now that it looks like dummy coil inductance is a problem, I'm thinking it is better to minimize turns to minimize the inductance.*

There is no reason one cannot use thicker wire, if there is space, so the coil need not be circular.

> *Also, I ran the equations for a 2" coil and it gave 1400 turns and about 50mH of inductance. But a 1" coil needs 5500 turns and has almost 1H of inductance, enough to cause audible effects when placed in series with a pickup. The 2" coil might do the trick but certainly, larger is better.*

We do seem to be going towards large. It may prove necessary to make the coil reasonably rigid, to prevent feedback, but the effect cannot be that strong, given the small number of turns and the small fraction of the flux from the pickup magnets that will link the dummy coil.

> *I would like to be able to measure AC impedance and I recently found my Cornell-Dublier decade capacitor box, so assuming the caps haven't drifted out of cal, I can use it in an impedance bridge. I'm using an HP Model 202C signal generator and I'm pretty sure those were designed for use with impedance bridges.*

I also have a very old Cornell-Dublier "Decade Capacitor", model CDB3 (+/- 3% accuracy).

The capacitor I use in the Maxwall bridge is a 150 nanofarad Vishay/Roederstein polypropylene film capacitor, 5% accuracy, from Mouser (part number MKP1841415404). The actual capacitance is measured with a DMM, and the measured value is used in computations. Polypropylene capacitors are cheap but very stable, so they make nice secondary standards. One can buy 1% units, for added money, and skip the calibration step.

The fixed resistors are ordinary 5% carbon film 1/4-watt 10 Kohms, which cost ~4 cents apiece. Likewise, one can buy 1% units.

The potentiometers are heavy-duty carbon composition, although this isn't that critical. But, don't use cermet, as it wears out too fast.

The game is to adjust the pots until the bridge balances, then disconnect them from the bridge and measure their resistances with a DMM.

> *For now, I really think it is a good idea to experiment with steel and aluminum slugs in this pickup bobbin. Aluminum will tell me how much impedance change is caused by eddy currents and steel will give me an idea of how much permeability really affects the pickup inductance.*

Thanks. Copper may be better than aluminium, unless pure aluminium is available, as the alloys vary greatly in conductivity. Home Depot sells very thick solid bare copper wire, used for grounding electrical systems. I have bought much #8 wire (0.128" diameter), and they had thicker. (I see below that you already have some copper.)

> *I have a feeling that pickups are very, very poorly designed inductors and they don't make full use of the permeability of the core. That's why I*

> *only measure 5H for a steel-pole pickup even though the permeability of the core material is many hundreds of times higher than that of Alnico.*

True. The reason is that the magnetic circuit isn't closed, being more airgap than iron.

> *For steel poles, I thought I'd use music wire from a hobby store. The same music wire is sold everywhere so my experiments can be repeated my anybody.*

Music wire is very hard, and may not make that good a pole material. Music wire is more likely to be a good magnet material.

I would try black iron wire instead. The iron oxide finish may not be quite good enough an insulator, but this is nothing a single coat of ordinary varnish won't fix. Straighten the wire, varnish it, let it dry, cut wire into lengths, assemble lengths into a core.

How to straighten the wire? Attach one end to something strong, and the other end to a piece of waterpipe. Pull on the piece of waterpipe, stretching the wire. It will now be straight. This may take a lot of force. Apply varnish by running a piece of varnish-soaked cloth down the wire as it is held straight by its ends.

I have or had an old (1920s?) telephone hybrid coil that used insulated black iron wire for its core, with the copper windings on a slit brass tube with wooden endpieces, the windings being covered with green painted muslin sheet. I built a working telephone using this in the 1960s, and used it as my shop phone. All the parts were spread out one deep on a piece of plywood nailed to the concrete basement wall. This greatly impressed the various phone men who came by, and they stopped asking why this or that odd thing had been detected at the central office.

> *I also have some copper rods I could machine and that would give a known value for resistivity. But first, I'm going to try dropping some steel screws in the bobbins and see how the inductance changes.*

Also try some non-magnetic stainless steel screws?

Some of the physically stronger stainless steel alloys are magnetic, so it pays to check.

From:	moocow
Date:	☑ 1/27/2005 3:36 PM
Subject:	**Re: Dummy coil experiments - Moocow?**

Joe, I still haven't made an impedance bridge, but I did make the music wire poles for the Jackson pickup. I measured the inductance using my cheesy signal generator method but this time, I measured at 1kHz, 400Hz, and 120Hz. The 1kHz and 400Hz measurements agreed very closely, both calculated to 4.51H. But the 120Hz measurement was different, 3.12H. I tried some other numbers in my equations and it seems the equations are very sensitive to error at this low frequency. A small change in voltage becomes a large change in calculated inductance. I believe that at this low frequency, the coil looks mostly resistive and the inductance isn't contributing very much to the total impedance of the coil. In other words, the inductance value can be different and still give the same kinds of voltage readings. At least, that's how it is in the setup I'm using. Hopefully, an impedance bridge would work better but it seems to me that the less 'active' the inductance is, the harder it is to measure.

Even so, I'm still confident in the inductance measurements. The 1kHz and 400Hz numbers agree, which surprises me since I thought the change in AC resistance would cause at least some difference in the readings. But if you saw the frequency response plots I posted, you'll see that using my inductance numbers in a PSpice simulation gives a very good prediction of the measured resonant frequency. This wouldn't be the case if my calculated inductance values were too far off. I'm sure the Extech meter and impedance bridge would give better values but for now, I'm confident that my numbers are very close to where they should be.

I still have to make the brass poles for the pickup. That music wire is pretty hard, so I'm hopeful that the brass slugs will be somewhat easier to make!

START NEW THREAD	REPLY	PREVIOUS	LIST

From:	moocow
Date:	☑ 1/19/2005 10:24 PM
Subject:	**Presence**

I thought a bit more about how to compensate for the frequency response change caused by adding the inductance of the dummy coil in series with the pickup. The problem is that the extra inductance causes a shift in the resonant frequency of the pickup/guitar cable response:

http://home.comcast.net/~bcbarrera/files/pickup/Dummy_Coil.gif

The plot was created using PSpice where the pickup is modeled as an RLC circuit in series with an ideal voltage source. The guitar volume/tone control pots and capacitor, guitar cable capacitance, and amplifier input resistors are also part of the simulation, and the output is taken at the input grid of the guitar amplifier. The green line shows the normal EQ curve created by the guitar pickup impedance and guitar volume/tone control, etc. circuitry. The red line shows the EQ curve when the dummy coil is placed in series with the pickup. It lowers the resonant frequency and the height of the resonant peak is reduced. This simulation result corresponds well to the described loss of 'presence' caused by the dummy coil.

I thought it would be possible to add a capacitor in series with the dummy coil to create another R-L resonance that would be closer to the original resonant peak. A series capacitor will do this, but it will also cause a loss of low frequencies. To restore the lows, a resistor can be placed in parallel with the capacitor. Using PSpice, I was able to come up with a capacitor and resistor that would shift the resonant peak back where it belonged and restore the low frequency response to where it should be:

http://home.comcast.net/~bcbarrera/files/pickup/Dummy_RC.gif

This time, the blue line is the desired frequency response. The red line shows the effect of the series capacitor (.001uF) all by itself and the green line shows that the frequency response shape can be restored by adding a parallel resistance of 68K. Although the new response has a very similar resonant frequency and peak value, the overall signal has been attenuated by just over 4dB. In other words, the 'presence' can be restored by this simple RC circuit but it costs a 4dB loss in signal from the pickup. I'm not sure whether or not this is a good solution or not.

Another way to restore the original sound of the pickup would be to underwind both the pickup and the dummy coil. The problem is that the pickup and dummy coil have more inductance than the pickup alone, so by underwinding the pickup and dummy coil, their combined inductance can be reduced to the original value of the pickup. Assuming the inductance of both the pickup and dummy coil depend on the square of the number of coil turns, N, it is possible to calculate how much N should be reduced to give the lower inductances we desire. After a little algebra, we can calculate a scale factor that tells us how much to reduce the turns count:

scale factor = sqrt[Lpickup/(Lpickup + Ldummy)]

For example, the Jackson pickup I've disassembled had an inductance of 3.6H and with the magnets removed, it falls to 1.8H. The scale factor is then:

sqrt[3.6/(3.6+1.8)] = 0.82

This means I need to reduce the number of turns by 18% to get the combined inductance of the pickup and dummy coil back where they belong. If the original pickup had 6000 turns, the new pickup and dummy coil would have 4890 turns. The new pickup inductance should be 2.4H and the new dummy coil inductance should be 1.2H. Notice that the sum of the two is 3.6, the inductance of the original pickup. Also, the DC resistances of the pickup and coil are going to be reduced by since the number of turns is lower. Unfortunately, this also means we lose some output from the pickup. Assuming the resistance and pickup output are reduced linearly with N, they will fall by 18%.

These lower values for inductance, resistance, and output are included in the simulation for the new 'scaled' pickup and dummy coil:

http://home.comcast.net/~bcbarrera/files/pickup/Scaled_Pickup_and_Dummy.gif

It shows that the new frequency response does follow the original response but with an overall signal loss of about 2dB. In other words, the presence is restored at the cost of a tiny bit of reduced output. The RC compensation circuit lost us a little over 4dB, so I would expect the signal losses to be more acceptable with the 'scaled' pickup and coil.

I should caution that these simulation results shouldn't be taken as 'reality'. I have ignored the effects of AC resistance, which tends to eat up some high frequencies. Even so, the simulations point us in the right direction because they give a good idea of what to expect from changes to our guitar pickups and circuits. In this case, the simulation helps explain why the dummy coil takes away some 'presence' from the pickup. Also, they tell us that the presence could be restored by using a parallel RC circuit to resonate with the pickup and dummy coil, but that there is probably going to be a noticeable loss of pickup output. Finally, it is possible to underwind the pickup itself to sound right when the dummy coil is in the circuit and the loss of output is probably not going to be noticeable.

The reality is that we would need to experiment with the RC circuit and see if it the signal loss is a problem or not, or even if it really does make the pickup/dummy coil sound right again. Also, we would need to experiment with an underwound pickup/dummy coil to see if that works any better. That 18% number might be correct or maybe fewer winds could be removed and still give good results. In the end, we have to experiment and let our ears tell us what works and what doesn't.

START NEW THREAD	REPLY	PREVIOUS	LIST

From:	**Andrew C.**
Date:	☑ 1/20/2005 4:42 AM
Subject:	**Re: Presence**

Moocow,

That is the most remarkable post in my time on the forum. Many, many thanks

I am going to buy the components at the weekend, and try it out in reality - this really could become a great strat!

Andrew C

START NEW THREAD	REPLY	PREVIOUS	LIST

From: **Dave Stephens**
Date: ☑ 1/21/2005 7:22 AM
Subject: **Re: Presence**

Andy: let us know if all this theory stuff actually works. I'm guessing that your middle coil won't need to be reverse wound reverse polarity with this kind of dummy coil setup, right? What did he say 50 turns around a 3 inch circle, you could just tape that under the pickguard around the middle coil maybe? this is going to be one interesting experiment for sure.....Dave

From: **Andrew C.**
Date: ☑ 1/21/2005 9:17 AM
Subject: **Re: Presence**

Hi Dave,

You are right, there is no need for a RWRP mid pup. It's kind of wierd flicking through the five-way and not having that on-off-on-off-on buzz continuum.

Actually at the weekend I wasn't going to try the 50 wind coil, more the adding caps and resistors to try to match the resonant frequency, and seeing if the dB loss is reasonable.

Taping it around the middle coil would not be good, because it might act as a pickup because of the magnetic field.

From: **Dave Stephens**
Date: ☑ 1/21/2005 10:05 AM
Subject: **Re: Presence**

Hmmm, yeah that leaves the queston where do you PUT a 3 inch 50 wind coil in a strat? Supposedly these coils have to be in the same axis as the pickups to work.

There is a guy who sells a printed circuit board that you hook your pickups to that goes under the pickguard who claims it elminates the hum, but if you read between the lines on his website he also says it changes the tone because its "more efficient."

I'm skeptical about all this myself.....

From:	**Dave Stephens**
Date:	☑ 1/21/2005 10:31 AM
Subject:	**Re: Presence**

Oooops, I was behind in the thread, no more 50 turn coils. I just dont know guys, dummy coils have never been very popular, one may as well work on a better noiseless pickup than hack out one's guitar, just my opinion. Now a noiseless pickup thread would be fascinating to read. And so is this one.....Dave

From:	**moocow**
Date:	☑ 1/26/2005 8:23 PM
Subject:	**Re: Presence**

Dave, Fender, PRS and Gibson have made guitars with dummy coils. The Blueshawk and the Powerhouse Strat both use dummy coils for noise reduction, but both use a normal pickup bobbin as the dummy coil. This adds too much inductance in series with the pickup and affects the sound. There's the story about SRV having a P-bass coil in his guitar and that would have caused a change to the frequency response of his guitar. It seems bass players are more accepting of dummy coils. Alembic was using dummy coils in the 70's, but once again, they used a pickup-shaped coil which makes the inductance problem worse. I found that Ibanez and some custom bass makers still use dummy coils. In their case, maybe they like the sound of the added inductance. I believe the problem is not dummy coil idea itself, but rather the way they have been implemented.

In the early 80's, Fender used a dummy coil system that used a circular coil. However, Fender changed hands soon afterwards and the dummy coil idea was dropped in favor of the Lace pickups. Look at the other thread on resonant frequency measurement and circuit simulations and you'll see that PSpice does a very good job predicting the frequency response of a guitar pickup. PSpice tells me that a dummy coil can work as long as its impedance is low enough, so I think it's worth a try.

By the way, I had calculated around 500 turns in a 3-inch coil. I picked that size to fit on the back of a Stratocaster plate. This way, I could experiment wih different coils without having to take the guitar apart every time. Also, people don't like to route out their guitars and I thought if you were trying to come up with something people would actually want to buy, this would be a good way of packaging and mounting the dummy coil.

Finally, I think it is better to get noise reduction by starting with a good pickup and making it quieter instead of starting with a bad-sounding noisless pickup and trying to make it sound good. Also, many noisless pickups are just a regular pickup packaged along with a dummy coil, so dummy coils are actually rather common.

START NEW THREAD | REPLY | PREVIOUS | LIST

From: **Andrew C.**
Date: ☑ 1/27/2005 11:01 AM
Subject: **Re: Presence**

Moocow,

I am with you, and have been rummaging around on the web for more dummy coil info...

It seems that Fender put out a well recieved Elite Stratocaster in 1983-4 that a lot of folks at harmony central still play and love. Some of them know there is a dummy coil, and some don't...but all the reviewers don't seem to care at all. Fender killed the product though.

The nighthawk dummy coil has a couple of conflicting write-ups, but it seems to be a dollar coin shaped coil mounted on the back of the volume pot. Haven't seen any pictures though, nor ever opened one up in real life.

I just tried this on a second strat and hey whats that? Shielding all over the pickguard...The first guitar didn't have a shielded pickguard so the dummy was picking up the same EMI interference as the rest of the coils. Now I have the problem of the dummy coil being behind the shielding and the actual pickup being "half-behind" the shielding.

Hmmm

START NEW THREAD | REPLY | PREVIOUS | LIST

From: **Steve A.** @
Date: ☑ 1/28/2005 9:23 AM
Subject: **Re: Presence**

Andrew said:

The nighthawk dummy coil has a couple of conflicting write-ups, but it seems to be a dollar coin shaped coil mounted on the back of the volume pot. Haven't seen any pictures though, nor ever opened one up in real life.

I had researched the Blueshawk, and as I recall the dummy coil is like a Blues 90 pickup without the magnet or pole pieces and is mounted on the backside of the guitar between the two pickups. (I did not find much on the Nighthawk. 😟)

You mentioned wanting to cancel more of the noise. I think I would be happy losing 80% of the noise while retaining 80% of the good tone from a single coil pickup. 😊 Another thought- even some humbuckers pick up some noise when plugged in near a TV or computer monitor...

Steve Ahola

START NEW THREAD	REPLY	PREVIOUS	LIST

From:	**Andrew C.**
Date:	☑ 1/27/2005 11:05 AM
Subject:	**Re: Presence**

Moocow,

When you say a three-inch coil, do you mean a circular coil with a diameter of three inch, or it that the bobbin core area?

Andrew C.

START NEW THREAD	REPLY	PREVIOUS	LIST

From:	**moocow**
Date:	☑ 1/27/2005 3:20 PM
Subject:	**Re: Presence**

The 3-inches referred to the average diameter of the coil. The idea was to make some rough calculations to see if a circular coil could have the same 'area' as a pickup, but with fewer turns and less inductance. I needed some numbers to put into the inductor equations so I chose 3" as the average diameter, with an inner diameter of 2.8 and an outside diameter of 3.2. The coil is assumed to be 0.20 inches thick. I honestly don't know if these dimensions are realistic but I have to start somewhere. The calculated inductance is very low, about 10mH, which is about 300 times smaller than the inductance of a single coil pickup. This tells me the dummy coil isn't going to add a significant amount of inductance to the pickup so the frequency response should be the same. In other words, there won't be a loss of 'presence' caused by the dummy coil. This morning, I ran the equations for a 2.5" average diameter coil and I get an inductance of 33mH, still a small number but it's easier to fit onto the backplate of a Stratocaster.

These calculations are very rough and they are not intended as design equations. The point is to take a guess and see if it is worth a try. If the numbers showed me there was a lot of inductance, then I wouldn't have even brought up the subject. But the estimated inductance is extremely low so I so they tell me this is worth a try. They also tell me that using a pickup bobbin as a dummy coil is a bad idea because it maximizes the amount of inductance in the coil. So even though my numbers aren't very realistic, they do lead me to some useful conclusions.

The next step is to wind some coils and see what the inductance really is. Also, there needs to be a way to measure the noise output of a pickup so I can design a coil properly. I had to make an assumption as to how many turns were on the pickup but I don't know for sure. If I could somehow measure the noise from the pickup, then I could tweak the dummy coil design until it put out the same amount of noise. Otherwise, there would be a risk of either underwinding or overwinding the dummy coil and not achieving as much cancellation as possible.

START NEW THREAD	REPLY	PREVIOUS	LIST

From:	**Sheldon Dingwall** @
Date:	☑ 1/27/2005 1:16 PM
Subject:	**Re: Presence**

"It seems bass players are more accepting of dummy coils. Alembic was using dummy coils in the 70's, but once again, they used a pickup-shaped coil which makes the inductance problem worse. "

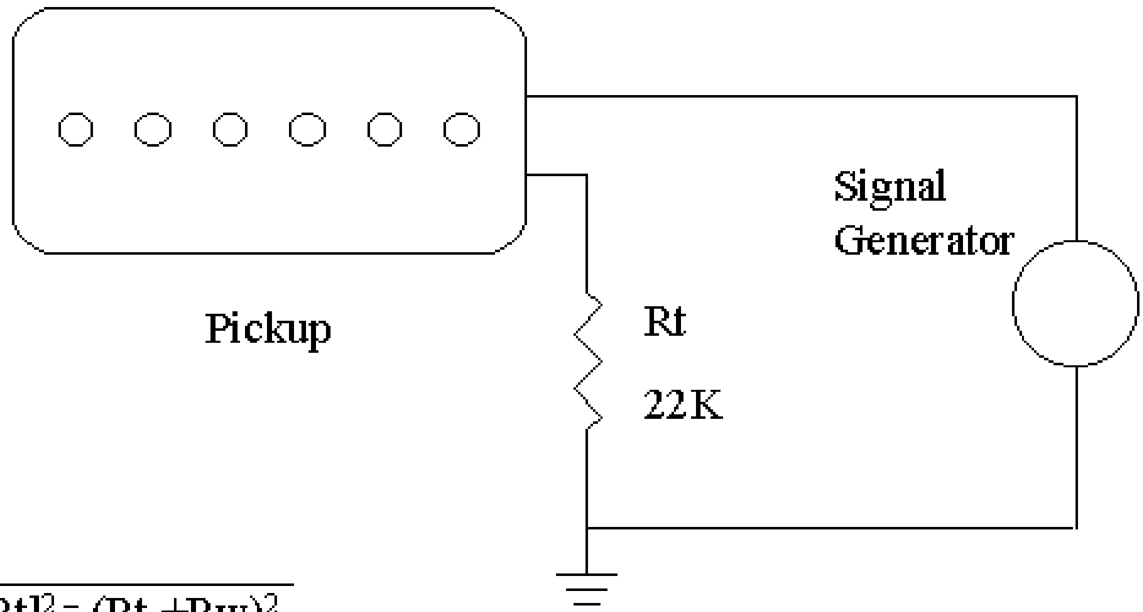
I'm pretty sure Alembic has always buffered the dummy coil from the pickups so inductance was never an issue.

START NEW THREAD	REPLY	PREVIOUS	LIST

From:	**Dave Stephens**
Date:	☑ 1/28/2005 1:34 AM
Subject:	**Re: Presence**

Moocow I have kept up with published info on SRV's Number One guitar, and when Fender dissected it there wasn't a dummy coil in it. They did say the the "bobbins were shielded" but no explanation of how this was done. I don't think bass players are as interested in a fuller tone that guitar players are because they are playing bass so some of the higher frequencies lost in noise cancellation don't matter to them. I did read on the net some post that a guy tried the Pbass dummy coil and he said it worked incredibly well, whatever that means.

I am really interested in how this idea of yours works in real life and I would mess with it but I am swamped with album design work and pickups too. What gauge wire would this 3 inch coil be? It sounds like you are saying it would have to be hand wound on a flat surface kinda like an old radio antenna? I'm vague on how a dummy coil is wired, in series with all the pickups? Dave



$$L = \frac{\sqrt{[(Vg/Vr)Rt]^2 - (Rt + Rw)^2}}{2\pi f}$$

where

L = pickup inductance, Henries
Rw = pickup winding resistance measured by DMM, ohms
Rt = fixed test resistor, ohms
f = test frequency, Hz (usually 1000Hz)
Vg = Generator voltage
Vr = Resistor voltage

Example:

When Rw = 5980, Rt = 21700, Vg = 1.1V, Vr = 0.68V, and f = 1000Hz,

$$L = \frac{\sqrt{[(1.1/.68) \times 21700]^2 - (21700+5980)^2}}{2\pi(1000)}$$

$$= \frac{\sqrt{(35103)^2 - (27680)^2}}{6283}$$

$$= \frac{\sqrt{466038209}}{6283}$$

$$= 3.4 \text{ Henries}$$

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AlNiCo ISOTROPIC MATERIALS

TYPICAL MAGNETIC PROPERTIES

SGM Designation	IEC Designation	Remanence		Normal Coercivity		Intrinsic Coercivity		Maximum Energy Product	
		B_r(gauss)	B (mT)	H_{cB}(Oe)	H_{cB} (kA/m)	H_{cJ} (Oe)	H_{cJ} (kA/m)	$(BH)_{max}$ (MGOe)	$(BH)_{max}$ (kJ/m³)
F	AlNiCo 10/5	6700	670	585	45	615	50	1.4	11
ALX	AlNiCo 8/3	6300	630	400	30	415	35	1.1	9
HRF	AlNiCo 10/4	8100	810	470	35	485	40	1.5	12
HYS	AlNiCo 4/1	8400	840	125	10	125	10	0.5	4
HYNICO	AlNiCo 16/9	6200	620	1100	90	1190	95	2.2	18

OTHER TYPICAL PROPERTIES

SGM Designation	IEC Designation	Temperature Coefficient of Br	Density	Relative Recoil Permeability	Curie Temperature	Continuous Maximum operating Temperature	Recommended Magnetising Field		Tensile Strength	Transverse Rupture Force	Hardness
		%/°C	g/cm³	μ rec	°C	°C	kOe	kA/m	N/mm²	N/mm²	Vickers 10kg Load
F	AlNiCo 10/5	-0.02	6.80	5.00	780	450	2.5	200	190	300	510
ALX	AlNiCo 8/3	-0.02	6.70	6.70	730	450	2.0	160	190	300	500
HRF	AlNiCo 10/4	-0.02	7.00	5.30	800	450	2.0	160	190	300	515
HYS	AlNiCo 4/1	-0.02	6.85	18.00	730	450	1.0	80	190	300	500
HYNICO	AlNiCo 16/9	-0.01	7.15	3.10	860	550	3.8	300	170	300	600

AlNiCo ANISOTROPIC HIGH REMANENCE MATERIALS

TYPICAL MAGNETIC PROPERTIES

SGM Designation	IEC Designation	Remanence		Normal Coercivity		Intrinsic Coercivity		Maximum Energy Product	
		B_r (gauss)	B_r (mT)	H_{cB} (Oe)	H_{cB} (kA/m)	H_{cJ} (Oe)	H_{cJ} (kA/m)	$(BH)_{max}$ (MGOe)	$(BH)_{max}$ (kJ/m³)
ATA	AlNiCo 35/5	11800	1180	650	50	670	55	4.6	37
APB	AlNiCo 35/5	12600	1260	590	45	610	50	4.6	37
AT	AlNiCo 33/6	11600	1160	680	55	705	55	4.3	34
AF	AlNiCo 30/6	11000	1100	720	55	755	60	4.0	32
AFA	AlNiCo 26/6	10000	1000	750	60	800	65	3.4	27
APF	AlNiCo 26/6	11000	1100	800	65	835	65	4.0	32

OTHER TYPICAL PROPERTIES

SGM Designation	IEC Designation	Temperature Coefficient of Br	Density	Relative Recoil Permeability	Curie Temperature	Continuous Maximum operating Temperature	Recommended Magnetising Field		Tensile Strength	Transverse Rupture Force	Hardness
		%/°C	g/cm³	μ rec	°C	°C	kOe	kA/m	N/mm²	N/mm²	Vickers 10kg Load
ATA	AlNiCo 35/5	-0.02	7.20	3.80	860	550	2.5	200	190	300	530
APB	AlNiCo 35/5	-0.02	7.20	3.70	860	550	2.5	200	190	300	530
AT	AlNiCo 33/6	-0.02	7.20	4.00	860	550	2.5	200	190	300	530
AF	AlNiCo 30/6	-0.02	7.20	4.30	860	550	2.7	215	190	300	530
AFA	AlNiCo 26/6	-0.02	7.20	4.30	860	550	2.7	215	170	300	530
APF	AlNiCo 26/6	-0.02	7.20	4.20	860	550	3.0	240	170	300	530

AlNiCo ANISOTROPIC HIGH COERCIVITY MATERIALS									
TYPICAL MAGNETIC PROPERTIES									
SGM Designation	IEC Designation	Remanence		Normal Coercivity		Intrinsic Coercivity		Maximum Energy Product	
		B r (gauss)	B r (mT)	H cB (Oe	H cB (kA/m)	H cJ (Oe)	H cJ (kA/m)	(BH) max (MGOe)	(BH) max (kJ/m3)
HCF	AlNiCo 12/6	7400	740	730	60	770	60	1.8	14
HC1	AlNiCo 19/7	8100	810	845	65	900	70	2.5	20
HC3	AlNiCo 36/12	8300	830	1480	120	1540	125	4.8	38
HC3A	AlNiCo 37/11	8700	870	1430	115	1485	120	4.9	39
HC3B	AlNiCo 40/12	8650	865	1550	125	1615	130	5.5	44
HC3C	AlNiCo 41/10	9800	980	1280	100	1320	105	5.4	43
HC4	AlNiCo 37/15	7200	720	1840	145	1920	155	4.7	37
HC4A	AlNiCo 41/13	8100	810	1700	135	1790	145	5.4	43

OTHER TYPICAL PROPERTIES											
SGM Designation	IEC Designation	Temperature Coefficient of Br	Density	Relative Recoil Permeability	Curie Temperature	Continuous Maximum operating Temperature	Recommended Magnetising Field		Tensile Strength	Transverse Rupture Force	Hardness
		%/°C	g/cm³	μ rec	°C	°C	kOe	kA/m	N/mm²	N/mm²	Vickers 10kg Load
HCF	AlNiCo 12/6	-0.01	7.00	4.70	810	550	2.7	215	190	300	520
HC1	AlNiCo 19/7	-0.01	7.00	4.50	830	550	3.2	255	170	300	530
HC3	AlNiCo 36/12	-0.01	7.18	2.20	860	550	5.4	430	170	300	615
HC3A	AlNiCo 37/11	-0.01	7.18	2.20	860	550	5.2	410	170	300	615
HC3B	AlNiCo 40/12	-0.01	7.18	2.30	860	550	5.6	450	170	300	615
HC3C	AlNiCo 41/10	-0.01	7.18	2.20	860	550	4.6	370	170	300	615
HC4	AlNiCo 37/15	-0.01	6.95	1.90	860	550	6.7	530	170	300	630

HC4A	AlNiCo 41/13	-0.01	6.95	1.70	860	550	6.3	500	170	300	630

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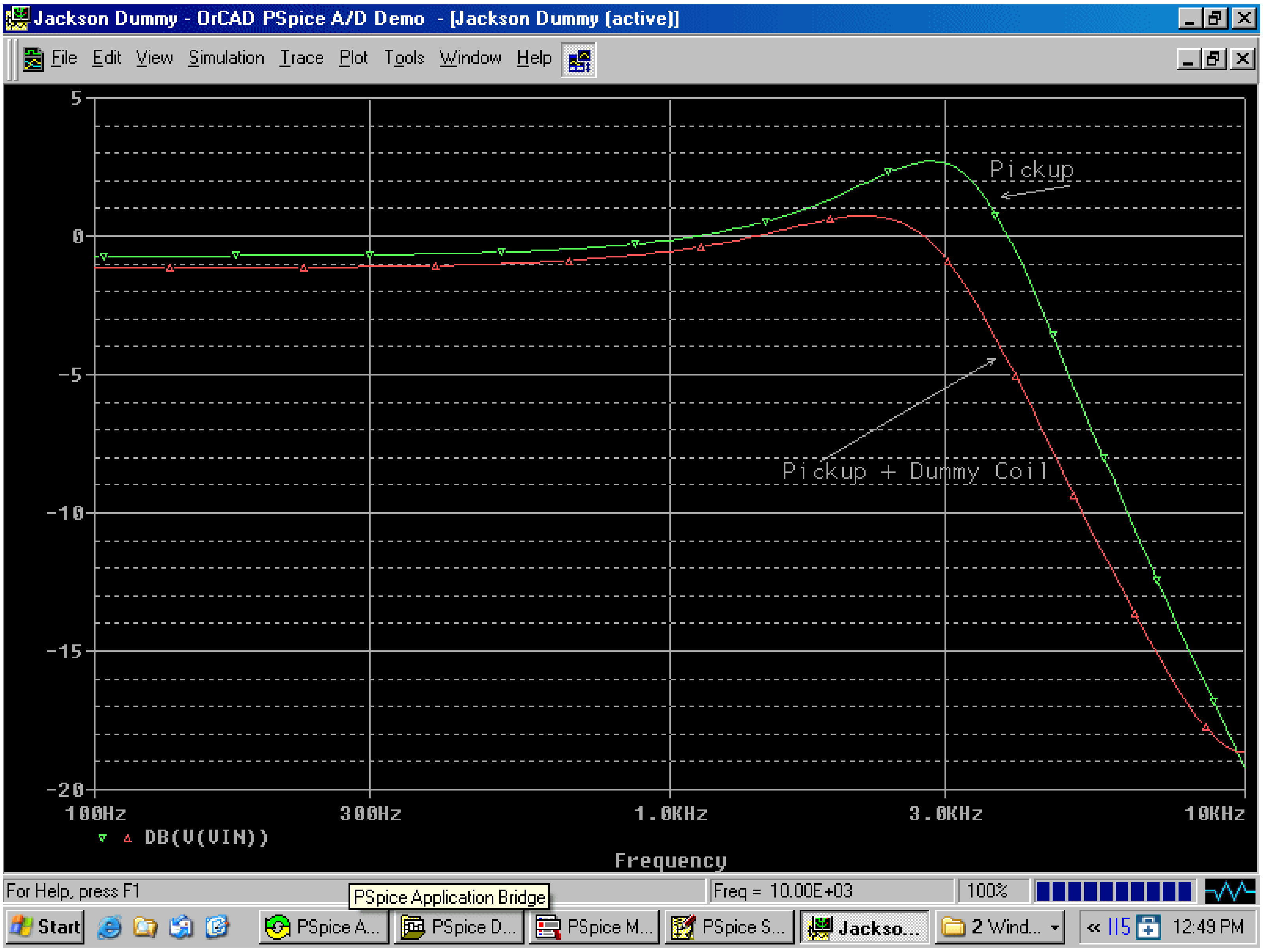
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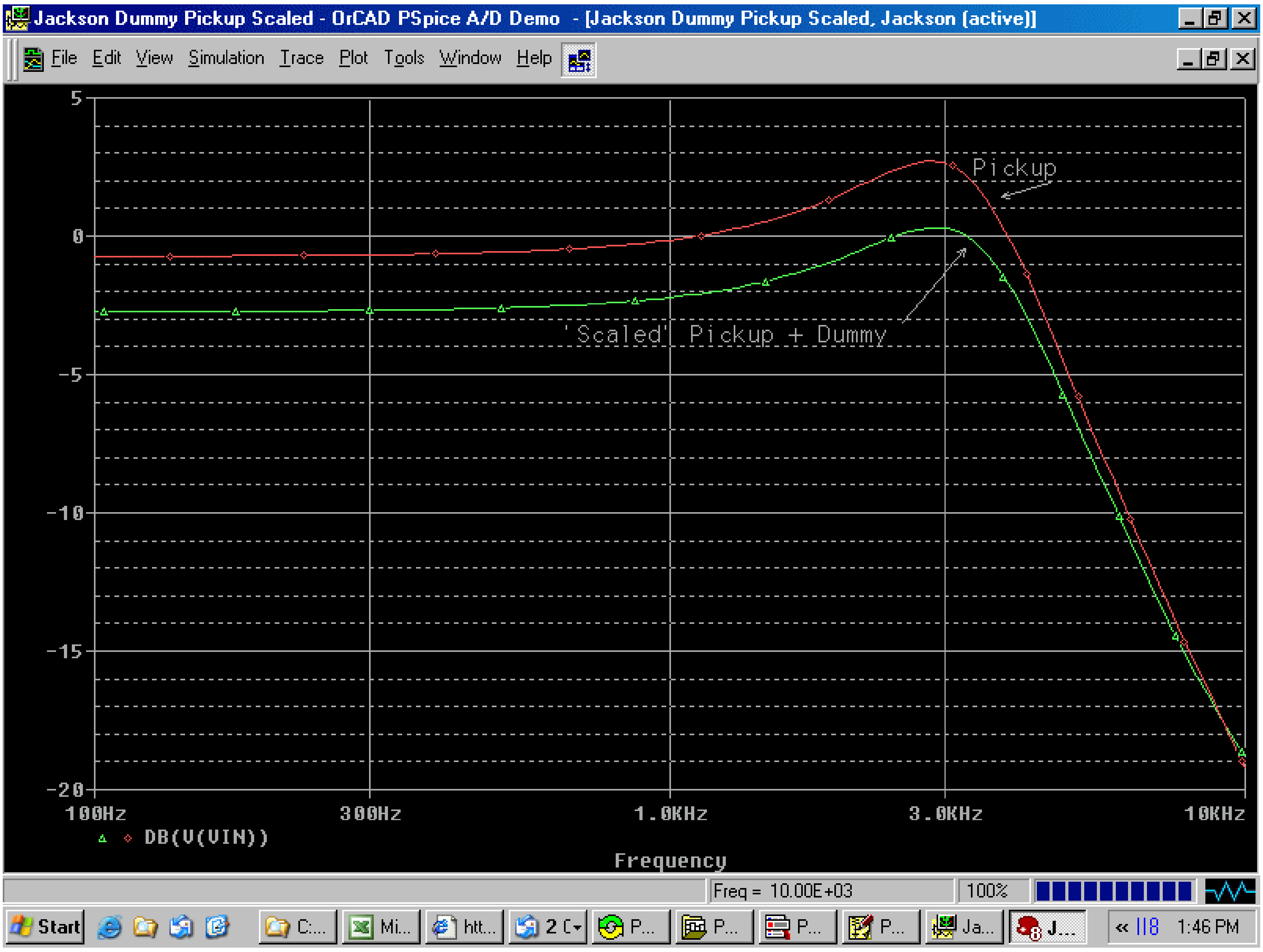
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