# Servicing musical instrument electronics

By Ron C. Johnson

In past articles I've suggested a number of ways you and your shop could use expertise you already have to diversify into new areas. Your test setup, personnel and skills are transferable from one service area of electronics to another. Moving into a new area really isn't all that difficult. The trick is to find an area that's profitable. One of the goals of this column is to help you do that.

Since traditional consumer electronic servicing includes audio equipment such as tuners, receivers and power amplifiers, servicing musical instrument electronics is just a small step away. In this issue I'd like to talk about some technical and some non-technical aspects of musical instrument electronic servicing that may be of help to you.

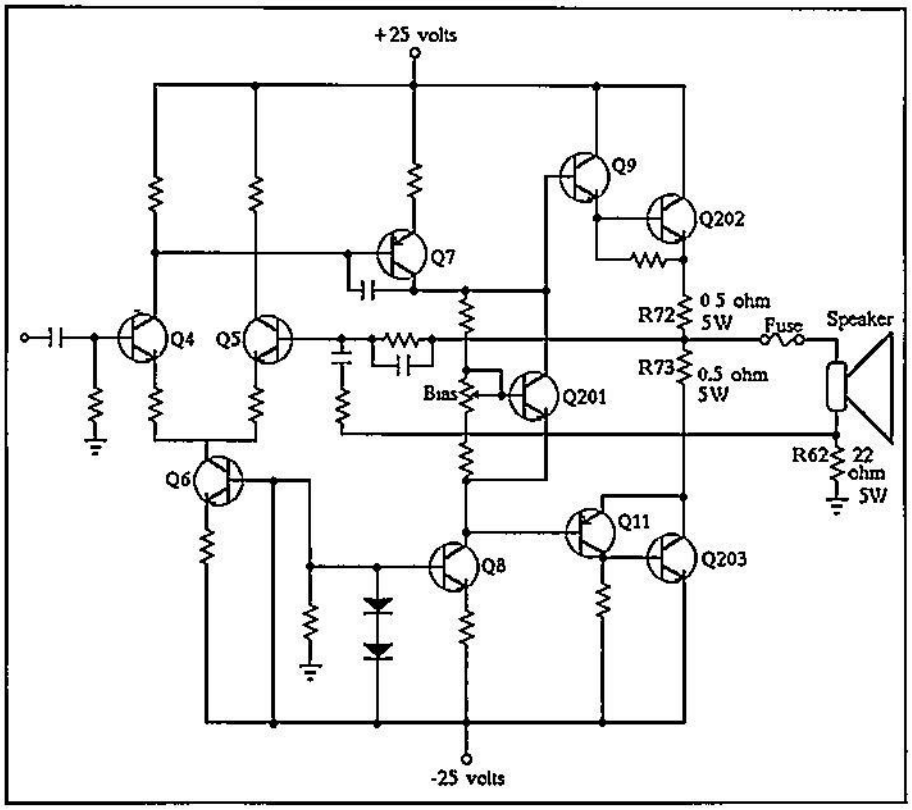


Figure 1. The output stage of a typical musical instrument amplifier. This one, out of a Fender guitar amp, has been around for a few years, and hasn't changed much.

### A list of the equipment

In case you're not the musical type and are not familiar with the kind of equipment you'll find in a music store, here's a short list.

Musical instrument amplifiers for guitars, basses, synthesizers, etc. are the main items to be found here. Guitar amps usually have a built-in speaker system and the electronics are all over the map: transistor amps, linear power blocks, and even tube amps which deliver that special sound (some would say distortion) desired by musicians.

Another big area is sound reinforcement systems. Sound systems are often rented to bands. A typical sound system consists of sound mixers, equalizers, and effects (digital delays, reverbs, etc.) as well as heavy duty power amps and large speakers. System rentals take a lot of abuse from moving and from rough usage which can provide you with ongoing service work.

Synthesizers of all shapes and descriptions require service from time to time. Again, these are sometimes rented, and therefore often require repair. The level of technology in synthesizers is pretty high and can be a real challenge. MIDI, a serial communication system between synthesizers, is the heart of the latest equipment. You may have come across MIDI in personal computers that have multimedia options. Building or repairing custom MIDI interfaces and cables can add to your service income.

Electric guitars are being manufactured with an assortment of specialty pickups, active electronics and synthesizer interfaces. There is quite a bit of special knowledge required here but it can be found in a few good books on the subject. Mechanical repairs to the guitars (and other instruments) can provide some work too, if you have the expertise to do it.

### Fixing the cables

Cable repairs can keep you busy as well. Sound systems use "snakes," multiconductor cables for running multiple microphone lines from the mixing board to the stage. These get beat up and need work regularly, especially the connectors on each end. You can also build and sell them in your spare time. Building snakes isn't difficult but you need to keep costs down to be competitive.

Most music stores also sell and rent recording equipment, usually special multitrack recorders. Some of these recorders use cassettes, others use video tape cartridges, and some are reel to reel. Your ex-

Johnson is a journeyman electronics servicing technician and an instructor of technology at the Northern Alberta Institute of Technology in Edmonton, Alberta, Canada.

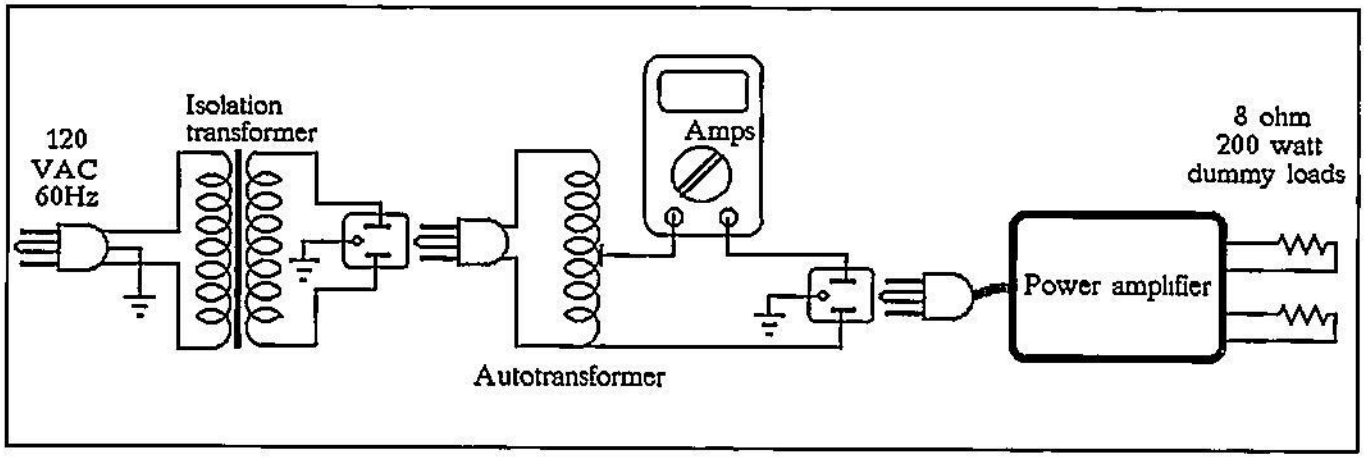


Figure 2. Use this set up to apply power to a direct coupled amp once you have completed servicing it. An isolation transformer feeds a variable transformer, and a special ac power cord (you make up) allows you to monitor ac current. You bring up the ac voltage slowly, watching the ac current.

pertise in VCR's and audio cassettes can be useful here

### Business considerations

Before we go on to talk about some of the technical aspects of doing this kind of work, some other business considerations are important. First, if the store is large, or if it is part of a chain, it may have its own service center and service personnel. The ones that don't, probably contract the service to a company such as yours, or they have somebody who comes in part time to do it.

If you find a music store that needs someone to perform their service, you'll have to decide whether to send one of your technicians to work at the music store or have somebody haul all the repairs back to your service center. This is no trivial matter. Often the music store wants service done at its location because some of this stuff is big and heavy.

We all know that it's difficult to make service calls profitable and this is no exception. Travel time to and from the store, acquiring parts, down time waiting for store personnel and other delays can erode your profit margin.

You need to get some questions settled at the outset of your relationship with the music store. For example, can you charge for checking out equipment that proves out as being good? It's important that you are organized and have a clear understanding with the music store.

If you have a work area in the store, is it yours exclusively? Some stores do speaker reconing and guitar adjustments but no electronics. When I was doing this kind of work I often came in on my assigned day to find the work area a mess. The store didn't like me charging them to clean it up but somebody had to do it. The final straw came when I found a pair of my needle nose pliers stuck to the workbench with spilled speaker cement all over them The store and I parted company not long afterwards.

### Technical considerations

Let's zero in on the technical end of musical instrument repairs and see some of the similarities and differences between what you're doing now and what you're likely to find.

Musical instrument (MI) power amplifiers have some similarities to the ones you see regularly The heart of a consumer stereo system is the power amp that takes signals from a preamp or receiver and drives the speaker system. The same is true of MI amplifiers. Guitar amps, for instance, usually have two channels of preamplification and an output driver. Sound system amps usually have one or two line level inputs to the power amp section.

While a typical consumer stereo amp is generally designed to be mass produced, MI amps have the added requirement of being ruggedly built to hold up under hauling them around, dropping them and driving them beyond their design limits. A number of other features further differentiate them from consumer amps For instance, MI amps have built in reverb circuits, tremolo, special filters, compressors and other effects. For now, let's take a look at the power amplifier section itself

### The musical instrument power amplifier

Some of the amplifiers you repair now may be capable of fairly high power output, but chances are most of the stuff you see is relatively low power and uses hybrid power ICs in the final stage Hybrid power ICs are used in some of the smaller practice amps and a few of the larger ones, but by and large you'll still find a lot of the good old Class AB push-push amplifiers A few of the newer amplifiers use VMOS FETs in their outputs, but, in my experience, being a bit unstable, they have never really caught on They tend to fail catastrophically, taking out several components at once.

You might be surprised at how many guitar amps still use tubes. Some of them use tubes throughout while others only use them in one or two stages. There's something about tube amps that musicians like. Although tube circuits do create some harmonic distortion, they cause less intermodulation distortion than solid state circuits. The result is a smoother sound, or so say the musicians.

### A real-world MI amplifier

Figure 1 shows the output stage of a typical musical instrument amplifier.

This one is out of a Fender guitar amp, has been around for a few years, and hasn't changed much I'll use it to point out some of the more common problems with this kind of amp.

This is a direct coupled Class AB amplifier that puts out about 40W RMS. Notice the final output transistors, Q202 and Q203 are both NPN with 0.5Ω, 5W resistors between them This is called a quasi-complementary symmetry amplifier. If an amp like this fails, usually one or both of the output transistors will short out.

If you encounter an amp like this one that's not working, always check the two resistors, R72 and R73, as they will often open up, and usually there is no visual indication that they carried excessive current. Another resistor to keep an eye on is R62, the 0.22Ω, 5W resistor that connects the speaker to ground.

Now take a look at the differential input stage to the amp (Q4 and Q5) The input signal is applied to the base of Q4 and a negative feedback signal is applied to Q5 The feedback signal comes from the junction of R72 and R73, which is also the actual amplifier output to the speaker The dc level at this point should be zero volts; the output current to the speaker should swing positive and negative around this point. The feedback voltage from this point reduces the overall gain of the circuit and minimizes distortion. It also serves to work against thermal runaway in the output stage.

Bipolar transistors drop in resistance as they increase in temperature. This causes more current to flow which causes them to get hotter In this case, if more current flows, the dc voltage at the output tries to climb This voltage is applied to the differential input stage and turns Q5 on harder As Q5 turns on Q4 turns off, increasing the voltage applied to Q7, and so on through the circuit acting against the original shift in dc operating point and stopping thermal runaway.

The point is that, if one component fails, it changes the dc bias throughout the circuit and can drive the output to saturation One nasty consequence is dc voltage applied to the coil of the speaker. This does interesting things to the geometry of the cone. Another consequence is the shorted transistors and open resistors mentioned earlier

## Servicing a direct coupled amplifier

The difficult part of repairing these kinds of failures is finding all the damaged components and replacing them at once If you don't, powering up the amp may blow up the brand new parts you just installed. You can hope that thoroughly checking all the semiconductors will catch all of the problems but I've become a bit nervous about flipping the power back on in cases like this

One method of testing to see if a fault still exists is to make up a power cord with a low wattage light bulb in series with the hot conductor. When you turn on the power, if the amp is still faulty and tries to draw lots of current, the bulb will light up brightly. The initial high resistance of the bulb may limit the inrush current enough to save the parts you have installed, if you turn off the power quickly enough—maybe—hopefully.

A better way to check your work is to use the setup shown in Figure 2. An isolation transformer feeds a variable transformer and a special ac power cord (you make up) that allows you to monitor ac current. You bring up the ac voltage slowly, watching the ac current. Most of these

amps will draw less than 1Aac with no signal applied If the current keeps on rising through about 1A as you increase the voltage something is probably still faulty in the circuit. Shut it down and start over.

By the way, the load shown is a dummy speaker load made up of two 200W, 8Ω resistors mounted on standoffs on a board. This is useful once you get the amp working to check for crossover distortion and symmetrical clipping at full output.

The unfortunate part of troubleshooting a circuit like this is that you seldom get a small problem with it. If one component changes the dc bias, everything goes out of line. Even a shorted capacitor will cause this kind of problem.

### The finishing touches

Once the amp is working, the only other consideration is the bias adjustment. The bias pot is what makes the amp Class AB instead of Class B. Its job is to bias Q201 on so that a fixed voltage is applied from the base of Q9 to the base of Q11 This voltage will just begin to turn on those transistors, as well as the output drivers, Q202 and Q203.

With a small base current flowing already, any ac signal applied will be amplified linearly. Without this, crossover distortion would result. Q8 is a current source (its emitter current is fixed by the two diodes from its base to the negative rail). Keeping the current through the bias circuit constant stops signal fluctuations from changing the bias voltage

There are a couple of ways to adjust the bias pot. One crude method is, with an input signal driving the amp, monitor the signal across the dummy load and adjust the pot for no visible crossover distortion. I'm sure you can guess how accurate that might be. A better way would be, with no input signal or load, to measure the voltage across the emitter resistor, R73, and adjust for about 12mV (about 25mA emitter current). Better yet, use a distortion analyzer and adjust for the specification given for the amplifier.

### After-service testing

Once the amp is working and the bias is set, about the only other check would be to apply a signal and check the output waveform across the dummy load. As you increase the input there should be no visible crossover distortion, and, when the output waveform reaches the power supply rails, clipping should occur on both peaks at the same time. For more critical checks you'll need a distortion analyzer or another specialized noise measuring equipment.

There is a real variety of interesting technology to work on in the musical instrument field and money to be made doing it. In addition to rental repairs and repairs to customers' equipment, warranty repairs are available. By making contact with equipment manufacturers through the music store you can become the authorized warranty center for the brands handled by that store and eventually widen your market to include others. As usual, good business sense and constant attention to the bottom line are just as important as technical ability.

In a future installment, I'll take a look at some other aspects of musical instrument servicing with some more tips on the technical end of the job. ■