Car Audio CAPERS

PART 2

Looking for better sound on the move? In part 2, Martin Pipe looks at the modification of existing equipment for external audio inputs and outputs.

You can CD point, can't you?

Last month, we looked at two car-audio related subjects. The first was how to install replacement speakers, while the second focused on 'pre-equalising' recordings that are tailored to the car's acoustics. Unfortunately, pre-equalisation isn't much help if you frequently listen to 'live' radio. The only solution here is to install a graphic equaliser, and adjust the tonal balance for best results. Unfortunately, very few car stereos give you the opportunity to break the internal link between tone controls and power amplifiers. Only high-end models have a line output, which can be used to drive graphic equalisers and external amplifiers of better quality (Maplin sells both varieties - check out the 'in-car entertainment' section of the catalogue). Fine, if you were planning to upgrade your stereo equipment to a better-specified unit. Unfortunately, aftermarket equipment tends to have a 'standard' DIN-E fitting. Many vehicles, notably modern cars (take the newer Fords, for example) tend to deviate from this standard and go their own way, making the installation of replacement units awkward - to say the least.

Another limitation of many car stereo 'head units' is that they don't make provision for an auxiliary input - such as a CD or Minidisc player. These digital sources sound somewhat better than cassette, with no wow and flutter, hiss or missing treble due to head azimuth alignment problems. Modern personal players don't jump or skip, thanks to the inclusion of 'anti-shock' buffer memory, and are hence well-suited to in-car use. If you're lucky, then your equipment will have a front panel-mounted 3.5mm stereo jack marked 'aux'. Sharp head units were among the first to include one of these, and these days even some of the cheap Far Eastern equipment has the facility. Some of the more expensive head units do, in fact, have a CD input, but it's intended only to be partnered with a CD changer from the same manufacturer. And guess what - there's no standard for the connection of such devices. The vast majority of these CD input features go further than simple audio connections. They also allow the CD player to be controlled from the head unit's front panel - a multi-way cable links the microcontrollers of both devices.

Because the switching and device control is so integrated, there's no easy way to 'force' the auxiliary input on, even if you could find out which pins on the 'CD' connector carried the audio signals. If you could obtain the circuit diagram of the unit, you may be able to find the switching chip. If you're lucky, it may be a discrete 4053-type analogue multiplexer so you may be able to switch the external input on by forcing the relevant switching input to ground or +12V via a toggle switch. Ah, if things were that simple! In my experience - particularly with modern units - the switching forms part of a microbus-controlled 'jungle' chip that also carries out other analogue functions. Note that circuit diagrams can usually be obtained from the manufacturer. Another good source for circuit diagrams - particularly if you're on a tighter budget - may be your local library. Some of the larger branches - notably Chelmsford in Essex - hold a good stock of manuals, and will obtain one for you if they don't have a copy. If you're not within convenient travelling distance of the library in question, your local one should be able to obtain it via 'interloan' for a small fee. Note, however, that service manuals from car manufacturers are very difficult to obtain. Fortunately, the equipment they build into their vehicles is usually bought in from other companies. As an example, Ford specified Philips gear for many years.

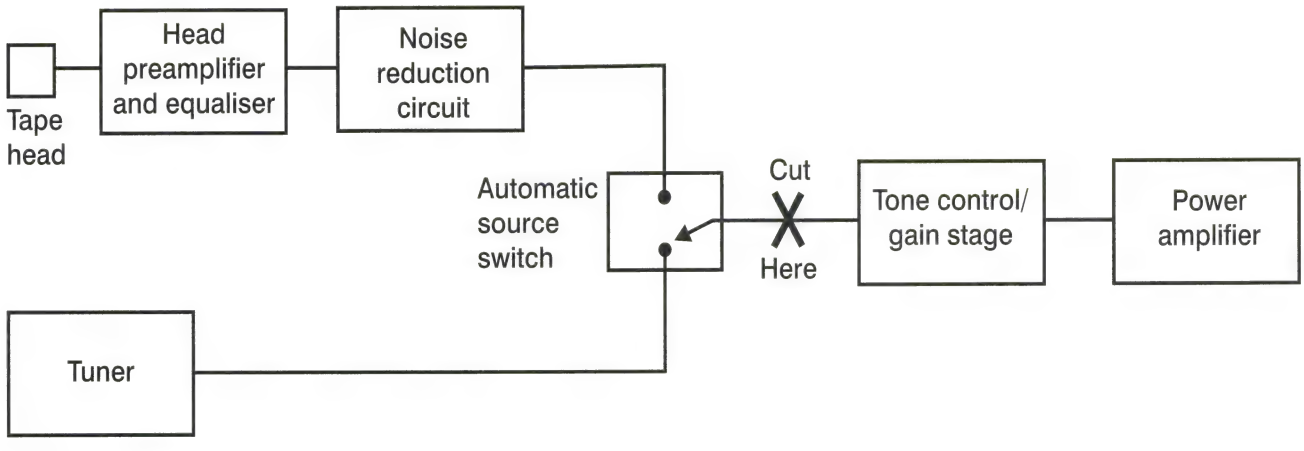


Figure1. Block diagram of typical car radio/cassette player

Modifying a Radio/Cassette Head Unit

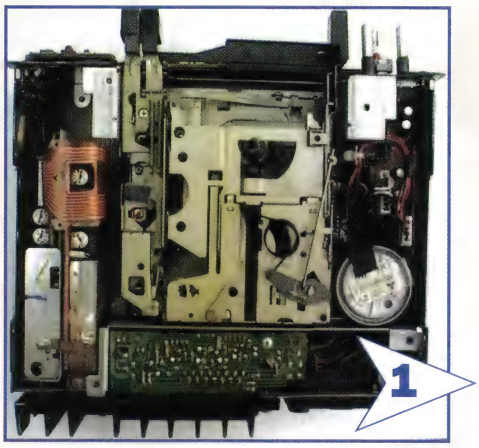
A sizeable proportion of the existing base of cassette/radio head units can be modified for greater flexibility. If the link (refer to Figure 1) between the automatic source selector - which selects the tape deck when the cassette is inserted, otherwise defaulting to radio reception - and tone controls is broken, and brought out to an external 'breakout box', then a lot of options are available to you. First of all, a graphic equaliser could be inserted into the loop. Secondly, the output could be used to feed external equipment, such as high-power amps, line-level electronic crossovers and graphic equalisers. Finally, the output from a CD player or other line-level devices could be introduced here. Although you can buy 'cassette adaptors' that allow signals from external audio equipment to be fed into your head unit, the sound quality is lacking compared to a direct connection. These cassette adaptors were, by the way, discussed in detail last month.

Line level? I have modified a couple of cassette radios in this way, and have discovered in both cases with an oscilloscope that the signal level at the tone control input is - fortunately - roughly line level (in other words, about 0.7Vrms). For the purposes of this article, we'll refer to one of these units - a Kenwood KRC5570 - throughout this article. Basically, the signal from the cassette head is boosted by a pre-amp, and then fed into a noise reduction circuit (where fitted). At this point, it's line level. The output from the tuner is at a similar level. The automatic source selector is thus switching between line-level signals. The automatic source selector's output is fed to the active tone control circuit - which usually also provides a bit of voltage gain. The tone control's output then goes, via potential dividers - the volume and balance controls - to the power amp ICs. It's impossible to generalise, and it's conceivable that your equipment may deviate. For example, the output from the source selector may be at a higher or lower level, the relevant amounts of gain being added further up the chain.

In these cases, you would need to make provisions - all external connections would need to be line-level for compatibility reasons. If the signal level at the point between the automatic source selector and tone controls is fairly low, then your CD input would need to be attentuated by means of a potential divider. If you wanted to drive line-level amplifiers, things get a little tricky. You would need to boost the signal - we would recommend a dual op-amp for this job. A TL072 dual opamp is fine for this kind of job, and will run off quite happily off the 12V DC likely to be in abundance inside your car stereo. If you want to

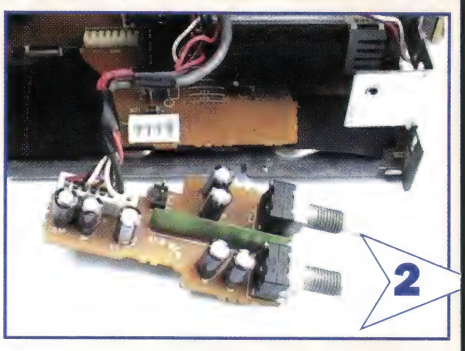
STEP-BY-STEP SPEAKER

STEP 1.



Here, the Kenwood's cassette mechanism has been unscrewed and unplugged for service. You also get access to the main circuit board. In some head units, the audio insertion point (the point between the automatic source selector and the tone controls) may be located somewhere on the main board.

STEP 2.



The Kenwood KRC-5570 cassette radio's tone control board, with audio in/out cable attached. Note the use of heat-shrink sleeving, and that the cable screen is connected to a convenient ground point. At the other end of the cable is a DPDT switch, which selects either the Kenwood's cassette/radio source or, via a pair of phono sockets, an external input. Fortunately, the break point was at line audio level - otherwise attenuators and/or gain stages would be required, depending on whether you require input or output. These are covered in the text.

STEP 8.

On the prototype, the in-line DIN socket that contains the audio signals has to be passed through the rear of the mounting cage. The breakout box, the cable of which terminates

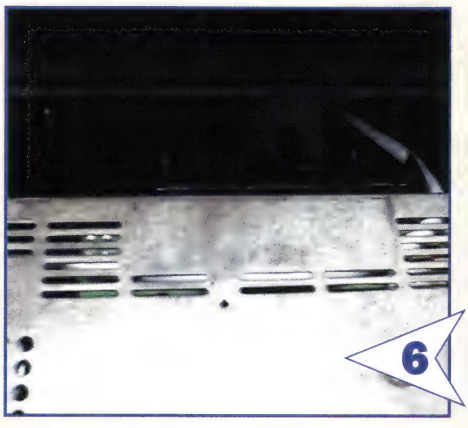
STEP 9.

The modified Kenwood head in use - here, a Diamond Rio is our audio source. Until somebody comes up with an in-car MP3 player, this is the next best thing!

STEP 7.

On the prototype, the in-line DIN socket that contains the audio signals has to be passed through the rear of the mounting cage. The breakout box, the cable of which terminates

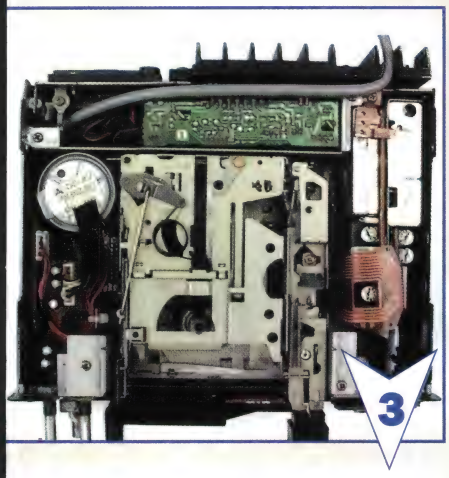
STEP 6.



Inserting the modified Kenwood head unit into its mounting frame. If your head unit is a removable design, you'll have to take similar precautions. Most modern units, however, are fixed into the car - as an anti-theft measure, a security code has to be entered if the unit is removed from the vehicle (this design is a complete joke, seeing that code reprogrammers are advertised openly in the trade press).

REPLACEMENT

STEP 3.



The Kenwood head unit, with tone control refitted and cable conveniently routed to the unit's rear.

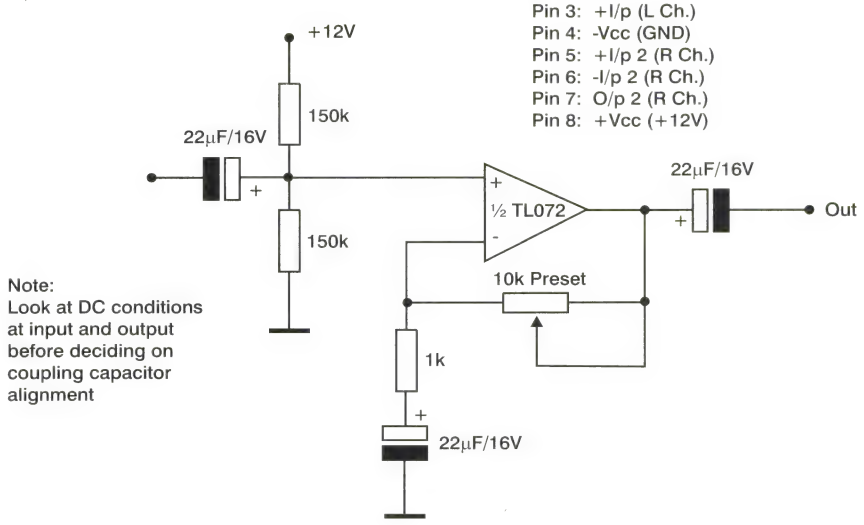
STEP 4.

Rear view of the modified Kenwood head unit. The unusual cable exit point on the back of the device is deliberate - this unit is 'removable'. This is one of the reasons for specifying the in-line DIN connections that can be seen to the left of the picture.

STEP 5.

The modified Kenwood KRC-5570 head unit, prior to installing it in the car.

Figure 2 Circuit diagram of single-rail audio amplifier based around TL072 op-amp. It may be needed to boost signals.



accurately match signal levels, I would specify presets as the op-amp gain-setting resistors. Note that you will need to bias the inputs at half-supply potential - op-amps were designed to operate on split-rail supplies - and couple the inputs and outputs via capacitors. Some vendors sell op-amps that are happy working on single supply rails, but the TL072 sounds good - one respected UK hi-fi manufacturer even used the device in a phono preamp! A suitable circuit is given in Figure 2.

Coupling Capacitors

Capacitor coupling may well be essential anyway, because there may be DC offsets at the audio switcher/tone control 'break' point of your particular car stereo. Remember this if you're using electrolytic capacitors to couple your inputs and outputs - orientation is important, and the negative side of the capacitor should be connected to the side of lower potential. A side-benefit of this approach is that the op-amps buffer the output of the source switcher, preventing loading (and possible volume reduction, as far as the head unit's own amplification is concerned). That said, most external amps have a high input impedance, and won't introduce any noticeable loading effects - I certainly haven't had any problems with my modified Kenwood unit, which didn't require any extra gain or attenuation stages. This is perhaps as well, if you're unfortunate enough to discover that the signal level at the point between the source selector and tone controls of your head unit is higher than line level. In this case, you will need additional gain to boost the line-level input from your CD player, and potential dividers to reduce the signal to a level compatible with external amplifiers.

I was very fortunate with the Kenwood, because its internal circuitry was laid out in a logical manner. I've seen similarly-designed head units from other manufacturers. Here, the (rotary) tone controls are built onto a separate PCB, with obvious screened leads for the input. The Kenwood tone control's DC supply and equalised output were interconnected by unscreened wires - presumably the active circuitry (a thick-film module) on the tone control boosted the level to such a point where interference was unlikely to be a problem. Modification was thus straightforward, which is perhaps just as well because I didn't have the service manual to hand! After investigating the signals with a 'scope, the tracks were cut on the PCB, and wires soldered to the relevant points (solder on the component 'lands' where possible, since these are mechanically sound). You'll need four wires - input left/right, and output left/right. I used Maplin's XR23A four-core individually-screened cable for neatness and practicality - I wouldn't recommend the cheaper 'overall screened' variety, which may result in crosstalk problems.

Modern Head Units

With more modern head units, things may be rather more different. Some are based around logic-controlled tone/volume controls, which are built into multi-function ICs governed directly by the microcontroller. With these, a service manual is essential if you want to find out whether the addition of inputs and outputs is a practical possibility - i.e., there's a suitable point in the audio path that can be broken. If there is, and you have to build additional circuitry into the unit, you have to ensure that there is sufficient room inside the unit. Note that most head units are somewhat densely packed with components. An alternative is to built the circuitry into the same external casing that contains the source switching and audio input/output connectors. Although XR23A is fine for the audio signals, we would recommend an additional heavy-duty wire to carry power to the op-amps. You could, I suppose, carry power via one of the audio wires - coupling capacitors at either end of the wire would block the DC from the audio signals. Whichever route you take, I would recommend inserting a low-value resistor or fuse at the head unit end - either would offer some kind of protection if the DC was to be accidentally grounded. Remember that we're dealing with a car electrical system here. Lead-acid car batteries are capable of delivering hundreds of amps - enough to start a fire in the event of a short

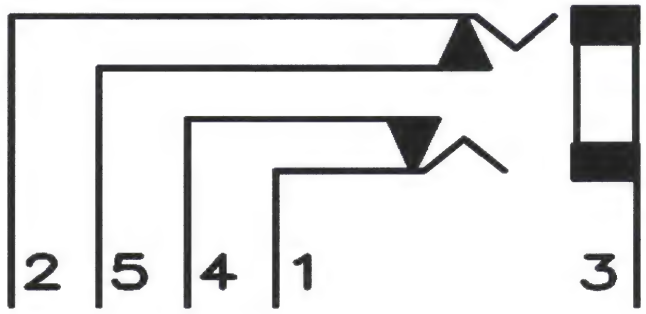


Figure 3 Architecture of JM20W 3.5mm stereo jack socket, which may be ideal for adding a front-panel CD input to your head unit.

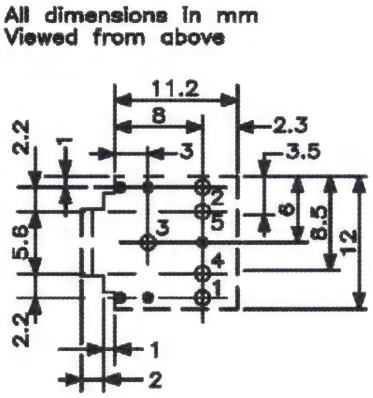


Figure 4 Dimensions of JM20W 3.5mm stereo jack socket

that allowed either the internal cassette/radio (from the automatic source selector) or external input to be experienced. As can be seen from the photographs, I used standard phono sockets for the external input. I originally considered fitting a line input socket, but there was insufficient space for even a 3.5mm socket.

You might be more fortunate with your unit's front panel design, although it has to be said that drilling front-panel holes may spoil its appearance! In any case, you might want to restore your equipment to its original condition, or add other features (such as the line output). If you only need an external input and are prepared to make holes in the front panel, choose a 3.5mm socket with in-built switch (such as Maplin's JM20W, shown in Figures 3 and 4). That way, there's no need to bother with manually switching the source. When no plug is inserted, the 'common' output pins (1 and 2) will make contact with the normally-closed (4 and 5) contacts. When the plug is inserted, the normally-closed contacts will be isolated, the jack plug making contact with pins 1 and 2 instead. Pin 3, meanwhile, should be connected to ground. Some head units with a front-mounted line input work along exactly the same lines. There are a couple of points you should be aware of, though. Firstly, JM20W is a PCB-mounted socket, and you must find some way of holding it in place - epoxy resin, perhaps (but make sure that none gets into the socket itself)? Secondly, there must be sufficient room inside the head unit to accommodate any active circuitry that may be required.

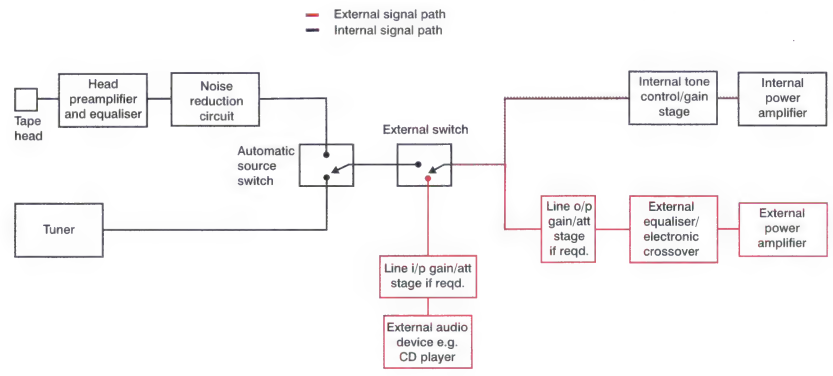


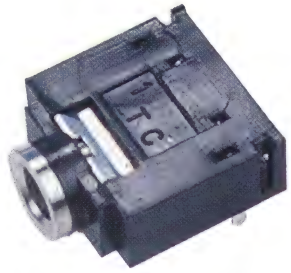
Figure 5 Block diagram of complete system

circuit - and should be treated with the utmost respect.

A metre or so of the four-core audio cable was brought out from the Kenwood unit to a 'breakout box' via a hole drilled in the rear panel. The positioning of the cable was particularly important, since the Kenwood can - like many high-performance units of its vintage - be 'detached' from its mounting frame to avoid theft. If you have a similar unit, you have to be very careful when deciding where to drill the cable hole, otherwise it may foul the rear of the frame - and the connectors not mate properly! Note that the Kenwood unit was only modified for line input - it already has a line output, courtesy of a trailing DIN socket. The breakout box was fitted with a DPDT switch

Is It Worth It?

OK, so it could be a lot of hassle - as you can see from block diagram Figure 5. You should only consider these modifications if your equipment is of a sufficiently high standard to make the effort worthwhile, or - thanks to the whims of the car's interior designer - there's no other option (such as replacement) available to you. If you take the time, the results are well worth it. I can now enjoy music from a variety of sources, and with far better sound quality than was possible from the old 'cassette adaptor'. I have successfully partnered the modified Kenwood with a notebook computer running Winamp (perfect for long journeys!), a Diamond Rio MP3 player, a Sony Minidisc Walkman and a Philips personal CD player. A subsequent modification was to break the 4-pin cable,



This 3.5mm stereo jack socket (Maplin order code (JM20W) has switching contacts, and is thus a good choice for simple auxiliary input modifications. Similar switching arrangements can be found in some cassette/radio head units with front-panel line-level inputs.

and wire up DIN connectors to each end. A 5-pin DIN plug was soldered to the breakout box end, while the head unit end of the cable was fitted with matching in-line socket into the cable.

For times when an external source isn't needed, the breakout box is replaced by a 'blanking plug' that restores original operation - in other words, the head unit's source output is fed directly to its tone control input. If you want to be more adventurous, you could consider automatic signal switching. With a logic probe or 'scope, hunt around on your personal CD player (or whatever) for a logic signal that goes high or low when a disc is playing. This could then be used to switch in the audio signal at the appropriate time with a relay or analogue multiplexer. A suitable control signal should be found near the CD player's microcontroller. We would recommend buffering the logic output with a buffer, or a pair of hex inverters (e.g. two of the gates of a 4069) wired in series. The switching circuitry could be built into a breakout box. Another possibility is a carphone mute - some cellular hands-free kits have a suitable logic output that goes 'high' during the course of a call. This output, which is intended for modern car audio equipment could, in our modification, switch transistors that ground the audio signals.

In the final article next month, we'll look at the installation of head units - plus anything else we haven't yet covered.

Watch It!

Maplin Electronics and the author accept no responsibility for your equipment, should you damage it whilst attempting modifications. So be careful!