SMALL CONSTRUCTION PROJECTS
FOR EXPERIENCED DXERS
Don Moman, VE6JY

Editor's Introduction

There has been an absence of listening-oriented construction projects of interest to serious SWBC and, to a lesser degree, MW DXers for the past several years. In seeking to fill that gap, the Proceedings staff asked well known DXer and *CIDX Messenger* Technical Column Editor, Don Moman to investigate and describe several projects, each of which can make a very real difference in our DXing and listening pleasure. The following project series covers several approaches to impedance transformers for listening antennas, a passive outboard RF notch filter, an audio/input receiver/recorder switch box, a static protection device for solid state receivers and an audio impedance transformation box. Each of these devices is very simple to construct and very useful/effective.

LISTENING ANTENNA IMPEDANCE TRANSFORMERS

In this section I will be taking a practical look at extracting better performance out of various listening antenna, especially the beverage, using a variety of wind your own toroidal transformers and commercial RF transformers from Mini-Circuits of Brooklyn, NY [1]. The design procedure for winding your own matching transformers has been well covered in previous issues of Proceedings but I will quickly run through the basics. These baluns are designed to transform 500 ohms, a "good guess" for a typical beverage, down to match your 50 ohm coaxial feedline. The transformer will be reasonably broadband when the impedance of the primary winding is 4 times the antenna impedance at the lowest design frequency, in this case 500 khz. To achieve a 2000 ohm impedance at 500 khz we need an inductance of .637 millihenries.

Desired L = 2000 / (6.28 x Frequency in khz) = 2000 / 3141.59 = .637 mH

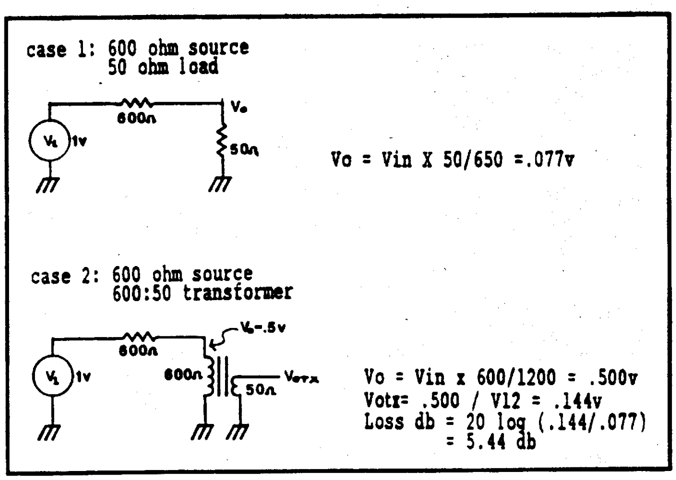
From this we look up the Amidon data for the core and use the following formula to determine the number of turns needed: Number of turns = 1000 x square root of (desired L in Mh divided by Al (mH per 1000 turns). This is the primary winding. For the secondary winding we can work through the above, using 50 ohms this time, or simply divide the number of turns in the primary by the square root of the ratio of input to output impedance. For these examples, that would be the square root of 500 divided by 50 or about 3.16.

Some practical beverage matching transformers:

Core	Al	Primary Turns	Secondary
FT 50-43	523	35	11
FT 50B-43	1140	24	7.5
FT 82-77	1170	23.5	7.5
FT 114-73	603	32.5	10

Expected losses due to impedance mis-match

How much signal improvement should we expect when we use the proper matching transformer? That depends on the degree of mismatch. With a source impedance of 200 ohms, we can expect a loss of 1.93 db using a 50 ohm load vs a 200 ohm load. If that 200 ohm load is the primary of a 4:1 transformer, and if the losses in the transformer are small, we can expect to recover nearly all of that 1.93 db loss. In a simple bench test, this was confirmed. The loss in the 4:1 transformer at 1 Mhz was too small for me to measure. If the source impedance is raised to 600 ohms, the loss will increase to 5.44 db. If the length of coaxial lead in is long there may be additional losses due to the mis-matched condition as well. A nearly 6db gain, achievable so easily just by matching, should not be overlooked!



An inexpensive source of ready made matching transformers is available from the previously mentioned Mini-Circuits. Their model MCL T9-1 has a 9 to 1 transformation ratio with less than 3 db loss over the .15 to 200 Mhz range. The MCL T4-6 has a 4 to 1 ratio over the .02 to 200 Mhz range. They are tiny, about a .25 inch cube. I mounted them on small scraps of PC board, as the leads are also quite delicate. They are available in a wide variety of impedance ratios and case styles. They are not designed to handle much power, 250 milliwatts maximum, so don't even think about trying to transmit through them! Some of the home made cores, such as the FT 82-77, are capable of handling considerably more power, I used 100 watts into such a transformer and beverage last summer on an listening expedition to complete my first two way contact on 160 meters with several amateurs in Australia.

Test Conditions

A 1000 foot, non-terminated beverage antenna, 5 to 6 feet above ground and running through fairly dense bush, is connected via a relay to the input of one of the two matching units under test. Either 50 ohm output is selected by a BNC coaxial relay. The signal then travels 700 feet via coaxial cable, much of it underground, to the radio room. Decibel values are derived from a previously calibrated S meter on a Yaesu FT-1000 transceiver. The relays are remotely switchable, allowing frequent A/B comparisons to counter the effects of fluctuating signal levels.

The various cores and transformers were mounted in small diecast aluminum boxes, with BNC connector output and binding post inputs. A "dummy" box was also constructed, with nothing in it but connecting wires to facilitate a direct antenna to 50 ohm connection.

Results

The first test was to confirm in practise what theory and Nick Hall-Patch have been telling me - there is a loss of approximately 6 db by just feeding the beverage directly into 50 ohm coaxial cable. Checking on a variety of signals from 100 khz to 15 Mhz, with most of the checks performed throughout the MW band, showed an approximate 6 db advantage with the MCL T9-1 unit over the dummy box. One exception was 5 Mhz where the MCL T9-1 unit was nearly 11 db better. In several cases, on weak daytime MW signals, the MCL T9-1 unit made the difference between no audio and readable audio.

A number of other transformers were tested, including handwound FT 114-43, FT 50B-43 and FT 82-77 units, and the various Mini-Circuits devices including the T4-6, T9-1, T16-1 and T36-1. The differences between any of the transformers were very slight, and were mostly due to the impedance variations of the beverage as the test frequencies varied. Values between 200 and 800 ohms all provided overall good performance, with higher impedance designs occasionally working well on a narrow range of frequencies, at which I'm sure the actual impedance of the beverage was quite high. Throughout all the testing, one result seemed consistent - the handwound transformer designs all showed a small advantage, typically 1 db at mid-band mw frequencies. Some of units were configured in combinations to provide other transformation ratios. Two MCL T4-6 transformers were wired in tandem to provide an impedance ratio of 16 to 1 or in this case, 800 ohms to 50 ohms. In actuality, tests showed it is not really this high in this and the following cases, more on the measured impedance later. At 100 khz, the T4-6 combination was 5 db better than the single T9-1. At 200 khz, the T9-1 was about 2 db better but that advantage was soon lost. Up to about 1000 khz the T4-6 combination was better by about 1 db, from 1000 khz to 20 Mhz I could find no differences. Wiring a T9-1 and a T4-6 in tandem yields a ratio of 36:1 or 1800 ohms to 50 ohms. This would seem to be getting a little high but the two units performed almost identically through most of the mw band. At 200 khz the T9-1 was better by 6 db, gradually loosing its advantage by 540 khz, and then gradually regaining about a 3 db advantage by 1400 khz, and maintaining that up into the SW spectrum. Wiring 2 of the T9-1 units for a 81:1 ratio (4050 ohms) showed a loss of 3 db through most of the mw band , with losses rising to 6 db or more at the extremes.

Wiring two of T4-6 units back to back gives a 1:1 ratio, but does it perform the same as the "dummy" box with no transformers? Yes it does, showing a consistent 6 db loss, compared to the T9-1 unit, from 200 khz to 15 Mhz. About the only reason for such a combination would be use it as an isolation transformer in a 50 ohm system, using separate grounds, which can be of some benefit in reducing noise and preserving the pattern of the antenna. On the test bench, this combination of T4-6 units showed negligible loss through the mw band, perhaps .5 db at 5 Mhz, 1 db at 10 Mhz, 2 db at 20 Mhz and increasing to 3 db at 30 Mhz. The dummy box still showed negligible loss at 30 Mhz, so all of the loss in the T4-6 setup was due to the transformers, not the layout.

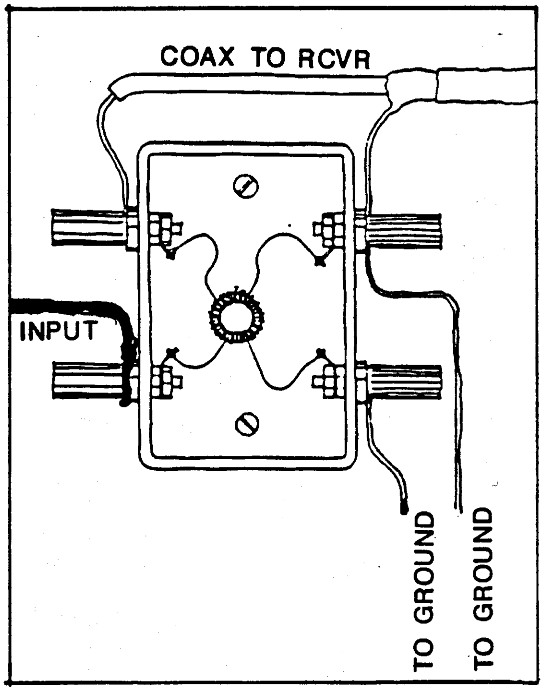
Next I used a isolated ground on the MCL T9-1 unit. The ground consisted of two 4 foot copper rods in moist soil. Signal strength results were typically identical to the non isolated test but with a few variances. A very significant noise reduction, in favour of the isolated MCL T9-1 was observed below about 300 khz. A fairly strong (S3) 60 hertz buzz, caused by my station's 12 volt DC power supply was just about eliminated. Other random noises, like static crashes also seemed to be reduced. The other thing I noticed was rather curious. Typically throughout the MW band the FT 114-43 was 1 db better than the MCL T9-1 unit, but on locals 630 and 680 khz it was 10 db <u>worse</u>. On 700 and 740 khz, the FT 114-43 suddenly was 10 db <u>better!</u> With other locals on 580, 790, 880 and 930 there was no difference.

So far, all of the listening tests have been using the same 1000 foot beverage. To sum up, almost anything other than a direct hookup will typically get you 6 db of more signal. Transformation ratios from a low of 4:1 (200 ohms) to a high of 36:1 (1800 ohms) were always a better choice than a direct connection. The "roll your own" baluns, using the larger cores showed a small but repeatable advantage, approximately 1 db in the MW band.

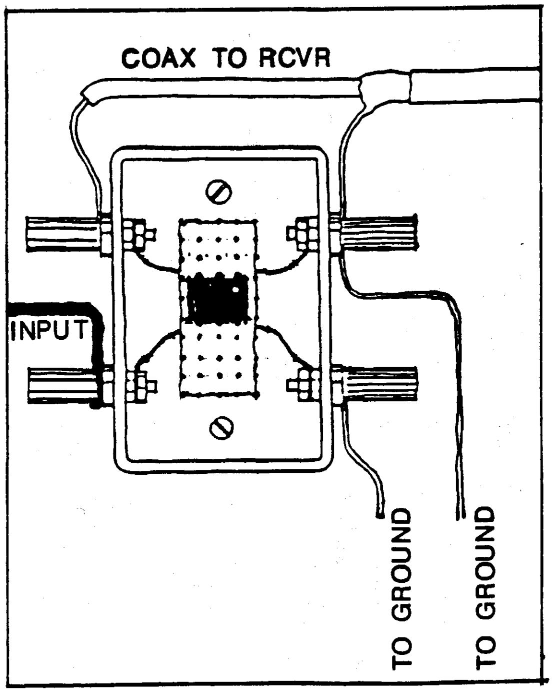
Matching Transformers with other Antennas

I thought it might be informative to try these transformers on my inverted L antenna, which has 60 feet of wire vertical and 70 feet horizontal. The ground system consisted of 4 ground rods in a very swampy area and 10 radials, mostly 100 to 125 feet long. It was roughly intended to be a quarter wave on the 160 meter band. On a variety of frequencies in the lower mw band, the T9-1 unit showed an average 6 to 10 db advantage over the dummy box. The advantage was down to 3 db by 1200 khz, 0 db at 1500 khz and above. By 5 Mhz and above, the T9-1 had regained a slight 1 or 2 db advantage. Comparing the T9-1 to T4-6, I found very few differences, with an occasional 1 to 2 db advantage going to the T9-1 below 900 khz.

These transformer designs would be very suitable for use with the T2FD antenna covered in the 1990 edition of Proceedings. This antenna is often designed around a 10:1 ratio transformer, although other values, such as the more common 4:1 unit would also work well in a receive only design.



TOROID-BASED IMPEDANCE TRANSFORMER



MICRO-CIRCUIT BASED IMPEDANCE TRANSFORMER

Bench Measurements of the Actual Impedance Values

As I hinted at earlier, it is not valid to assume that various transformers can be combined to maintain the various impedance ratios one might possibly assume from the products of their turns ratio. A test setup was constructed to measure the impedances of the various units. The output of the signal generator was fed through a variable resistor to the high impedance end of the transformer. The resistor was adjusted so that half of the generator voltage appeared across the transformer. At that point, the internal resistance of the generator (50 ohms) can be added to the variable resistors value, the sum of which must equal the transformers impedance . The test frequency was 1000 khz, although 3 Mhz was also tried, with very similar results. The T9-1 units showed a consistently lower impedance, 365 +/- 10 ohms as opposed to the expected value nearer to 450 ohms. The T4-6 units measured right on 200 ohms, and my other baluns all measured fairly close as well. At this stage I cannot explain the difference in the T9-1 values. In an earlier series of tests for Proceedings on the Mini-Circuit transformers as well as other home made types, Bill Bowers measured values of 444 and 490 ohms for his T9-1 units tested. To check my test procedure, I substituted a 470 ohm resistor for the balun and came up with 473 ohms. With a digital meter the resistor also read 473 ohms!

The Bottom Line

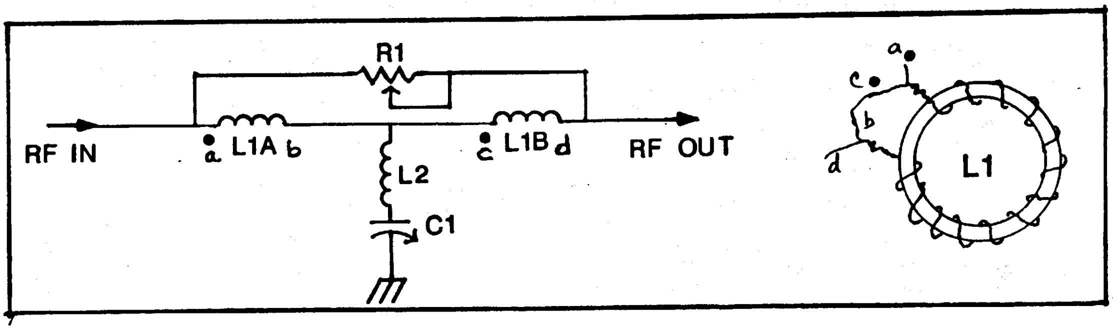
It seems that, for most receiving antennas, some form of matching transformer is a very good idea. The choice is yours, but it appears that whether you build or buy, it is hard to make a poor choice. Build a couple boxes with coax connectors and binding post inputs and see for yourself! Try them on whatever antennas you might have. Even if the antenna is designed to be resonant on a certain band, we often find ourselves using it on other frequencies where the impedances may be considerably higher. A matching transformer may often improve the signal, and virtually never harms the signal.

The tiny Mini-Circuit transformers come in many configurations including center tapped primary and secondary windings, and even some trifilar types with three isolated windings. It seems to me that these could be very useful in building phasing units and steerable two wire beverages.

Balun	Impedances Measured
T4-6	200
T9-1	365
FT114-43	535
FT 82-77	465
T16-1	575
T4-6 x 2	640
T4-6/T9-1	1030
T36-1	1300

My one concern about using these units are their delicate nature. Rated at only 250 mw of RF and 30 ma DC it seems possible that strong RF fields from nearby broadcast stations or even your own amateur radio transmitter could easily exceed their ratings. Induced energy from lightning strikes is often blamed for destroying the terminating resistor of the beverage so it's likely the transformer might also be damaged.

[1] Mini-Circuits, P.O. Box 350166, Brooklyn, New York 112325-0003 phone (718) 934-4500 or fax (718) 332-4661 [2] Amidon Associates, 2216 E Gladwick St., Dominguez Hills, CA 90220 phone (310) 763-5770



RF NOTCH FILTER

Many receivers are equipped with a notch filter, either in the audio or the IF stage of the set. An audio notch is useful to remove a fairly low level tone or heterodyne. The drawback is that this is done in the audio stage so if the offending signal is strong enough to activate the receivers automatic gain control (AGC) you will still find the desired signal will be desensed by the carrier, even though you may have removed all the audible tone. If the notching is done in the IF stage then you can remove the offending signal before it gets into the AGC. This is, by far, the most desirable of the two methods. But even the IF notch leaves the front end of the receiver, the RF amplifier and mixer stages subject to the strong signal and subsequent possible overloading and/or desensing. A tuneable RF notch filter in the antenna lead could be used to attenuate the strong signal before it gets to the receiver. If you are fortunate enough to have only one super strong signal bothering you, an RF notch may be a very useful gadget. I recall several listening expeditions where I managed to find a desirable location to set up beverages, only to find that there must have been a local AM station or longwave beacon just a few miles away! One super strong signal, along with the normal signals on the band, is all it takes to produce all sorts of spurious and mixing products, one of which is sure to interfere with what you want to hear. In this situation, the RF Notch filter would have been very handy. Preselectors and antenna tuners may also serve useful, but I want something I can set once and forget. It has always seemed very ironic to buy the lastest set with all the frequency agility provided by dual VFO's, 100 memory channnels, keypad tuning and then have to spend time adjusting the tuner or preselector.

The article that lead to me build an RF Notch filter was in the December 1983 issue of DX Australia's "DX'ers Calling", with an article written by Sam Dellit. He describes a notch filter constructed from information given in the August, September and October 1979 issues of "Wireless World". The article is titled "Passive Notch Filters" by G. Kalanit. From the design information presented in the article, the following configuration was derived.

L1 = 50 turns # 26 on Amidon FT 240-43 bifilar wound; L2 = 50 turns # 26 on Amidon FT 240-61;
R1 = 100 or 500 ohm carbon potentiometer; C1 = 365 pf variable capacitor

For L1, "bifilar" means twisting 2 wires together and then winding the coil, as in the above diagram. Twisting the wire together is easily done by inserting the ends of the wire in the chuck of a small drill Secure the far ends and then run the drill until the wires are nice and tight. The wire we are using is #26 gauge magnet wire which comes with a very thin but tough varnish that provides the insulation. Even after you twist the wires together you shouldn't be able to measure any continuity between the two strands. Be sure to observe the polarity when connecting the coils. According to the article, with these values, the unit covers the 531 to 1602 AM band very nicely. Sam reported a 3 db bandwidth of 15 khz, better than 60 db of attenuation with a bandwidth on the order of 100 hertz or less. Insertion loss was 5 db in a 50 ohm system and was very constant across the AM band.

I choose not to build this version as I did not have the FT 240 cores handy. They are quite large, 2.4 inches in diameter, since I had numerous other but smaller cores I came up with a combination that worked very well. I used the FT-50B-72 for L1, squeezing a maximum of 25 bifilar turns on that core. For L2, I first tried 50 turns on the FT-50B-61. C1 was a dual 365 variable. With this combination, the filter tuned from 250 to 1100 khz. A few more turns and one could cover the entire longwave and lower AM bands. Final adjustment of C1 and R1 are very touchy. The unit was built in a metal cabinet, and with the grounded capacitor design, no hand capacitance effects are noted. The leads from L1 were wired to back of a small DPDT toggle switch to allow the circuit to be bypassed. I used 100 ohms for R1, the 500 ohm version was just too delicate to adjust. This is a good point to interject that R1 must be of the non inductive type, so carbon is specified. Wirewound pots, fine in audio circuits, have far too much inductance to be used in RF designs like this. I also added a small panel mount trimmer across C1, likely a .5 to 15 pf type, size not critical. At the null point, the entire unit turns quite microphonic, so good solid wiring is a must. Don't set it near the radio's speaker, or there will be feedback.

I also experimented using a core with a higher Al value, which would result in fewer turns required for the same frequency range. I tried the FT-50B-43 with 13 turns and while it covered the proper frequency range, the null depth was very shallow. Nick Hall-Patch points out that the type 43 material is not especially high Q, whereas the type 61 and 72 cores I used initially are specifically mentioned in Amidon literature as being useful in high Q circuits.

Reducing L2 to 25 turns on the same FT-50B-61 core allowed the unit to tune from 600 khz up to about 2800 khz. On the test bench, notch depths varying from 40 to 55 db were noted. Insertion loss was typically 1.5 to 2 db throughout the SW bands. Insertion loss was only about .5 db at the 500 khz. Connecting the unit into the real world antenna, I found that it took a bit of practise to find the nulls. It actually worked best to switch the receiver to the CW narrow mode which uses a 250 hz filter, center that over the carrier and then tune for the null. R1 and trimmer across C1 should start at the approximate center of their travel, and C1 should then be adjusted slowly to find the notch. The notch may be quite shallow at this point, but with careful adjustment of R1 and C1 (use the trimmer for fine tuning) - it is an iterative process as both controls interact, the notch will deepen. Keep in mind what I said about the notch width at the null point, it is very sharp. It can remove the carrier from a local signal, to the point of severe distortion, but the sideband splash will not be eliminated. It will be reduced several db, a step in the right direction. I have several strong locals that contribute to mixing products showing up in the 160 meter ham band. In most cases, notching one of the strong signals at its fundamental will also remove the product. Using a vernier or at least some type of calibrated dial, would be a useful addition in a case like this, to make it easier to find the ballpark settings to notch the fundamental frequency.

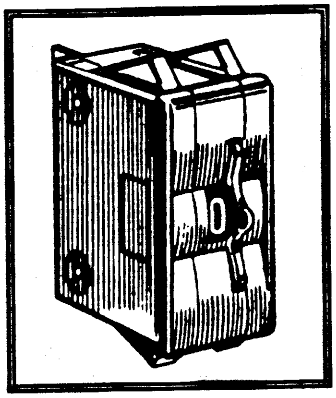
Notch Response

Test frequency was 1413 khz.

Frequency	Loss(db)
1413	55
1414	20
1418	10
1423	4
1433	3
1463	1.5
1513	1.5

This circuit could also be used to add an IF notch to a receiver, as long as the higher impedance, typically several thousand ohms, of the ceramic filter stages were accounted for in the design process. This circuit could be used to good advantage with a modern set using a high first IF with a 455 khz second IF. With the compactness of modern receivers, finding the room to add this circuit inboard would be nearly impossible, so one would have to break the signal path in the 455 khz IF stage and bring the connections out to the real panel. This quickly moves out of the realm of the simple construction project but it would be something to experiment with anyway, if you feel ambitious.

AUDIO INPUT/OUTPUT RECEIVER/RECORDER SWITCH BOX



I have built many different audio routing panels over the years, and each design has always been quickly outgrown, or for some other reason has fallen into disfavour.

The patch panel design, has all outputs and inputs brought into a panel or matrix of jack, then a number of short patch cords are then used to route each signal, much like the old telephone switchboards. The one advantage is good isolation between sources, but the disadvantages are numerous. They look messy with all the cords plugged in the front, switching sources isn't that handy, they take up a lot of room, and it's difficult to route one source to more than one output.

Rotary switches are fairly common, and for quite a few years I used a number of six position switches to route things around. It proved to be a fairly usable design and fed 6 receivers to 3 outputs. It was fairly large though, and by the time one wired up all the switches, you had a real tangle of wires back there. Isolation between channels also suffered unless you took extra pains to use shielded wiring and even then, all the connections to the various switches contributed to a fair bit of crosstalk.

My latest unit can switch 8 sources to any, all or any combination of 4 outputs. The front panel measures 5 inches wide by 1 inch high, and the unit is only about 2 inches deep. Wiring the complete unit only took about 5 minutes! The main ingredients are 8 BCD thumbwheel switches. These switches come in a great variety of configurations, the ones in my junk box were the 16 position BCD 1-2-4-8 type. They only have five solder terminals on the rear, the common, plus the 1,2,4 and 8 terminals. These switches are designed to stack side by side, so all you do to wire them up is slip a length of bare wire through all the "1" terminals, and so on till the "8"s are done. In my case, these were the four outputs to various tape recorders, RTTY decoders etc. The common terminal on each switch goes to one of the 8 audio sources. I used multiple RCA phono jack strips and soldered them to the back of the switches with very short lengths of bare wire. Simple, neat and compact! For those of you that know what a BCD switch does internally, you can skip ahead a paragraph! If you don't, stick with me. Lets go through the positions, obviously starting with "0" which means no connection. Position "1" connects the common to #1. Position "2" connects the common to #2. Simple so far, but here comes the difference. Position "3" connects the common to BOTH 1 and 2. Position "4" connects common to #4. Position "5" connects common to both #1 and #4. By now you should be seeing the pattern. Whatever number shows on the front of thumbwheel means the various output terminals that add up to that number are all connected to the common terminal. This is what gives the flexibility of the switch, any combination of the 4 outputs can be selected using one of the 16 positions. The only drawback is that a bit of mental gymnastics is required in the higher numbers to remember what is being connected. As I said, I used these switches because I had them, and I mention the BCD configuration because this is quite a common item to find surplus. If I had a choice, and especially if I was ordering some switches, I would opt for them in a "1 pole decimal" configuration. This is a 1 pole 10 position switch so the internal connections of the switch are obvious. Again, you would wire each of #1's together, #2's, etc. These would be your audio sources. Each of the common terminals would go to your various tape recorders, etc. With 9 switches, you could direct 9 inputs to 9 outputs. With a 9x9 matrix available, I'd suggest using some of the inputs as high level fixed tape outputs from the various receivers, and then wiring speaker level audio to some of the other inputs. In the same vein, some of the outputs could be wired to various speaker and headphones. The one unit could handle virtually all the audio switching that needs to be done,

Switch	OUTPUTS			
Pos'n	1	2	4	8
0				
1	x			
2		x		
3	x	x		
4			x	
5	x		x	
6		x	x	
7	x	x	x	
8				x
9	x			x
10		x		x
11	x	x		x
12			x	x
13	x		x	x
14		x	x	x
15	x	x	x	x

Inputs	Outputs 1 2 3 4 5 6 7 8 9
1	Receiver 1 tape out
2	Receiver 2 tape out
3	Receiver 3 tape out
4	Scanner 1 tape out
5	Spare
6	receiver 1 speaker out
7	Receiver 2 speaker out
8	Receiver 3 speaker out
9	Scanner 1 speaker out

1	2	3	4	5	6	7	8	9
Tape	Tape	Tape			Left	Right	Left	Right

Typical Configuration

with a minimum of complexity and space. The key here is complete flexibility. If you frequently need to connect two audio sources to one output, then you could solder two (or more, if needed) of the common terminals together to the one output.

Lest you get too carried away with all this convenience, and decide that this might be the perfect way to distribute all your antennas to your various sets, let me throw some cold water on that idea! They will switch your antennas but the isolation between the various antenna would only be minimal, and any directive properties would certainly be deteriorated. Even at audio frequencies, the isolation is only just adequate.

STATIC PROTECTION FOR SOLID STATE RECEIVERS

The components used in the front end stages of solid state receivers are quite easily damaged by high voltages. These voltages can be generated and find their way into the antenna input in many ways: nearby lightning strikes, precipitation static (rain, snow, and even sand particles blowing across the antenna), or static discharge as you walk across the carpet and touch the antenna. All of these have the potential to damage the set. The Sony ICF 2010 is one the best (or worst, depending on your point of view) examples of this, its RF stage FET was easily destroyed by static charges. It's impossible to safeguard against any damage but there are a few simple ways of reducing the possibility of static damage. Keep in mind that this is not even close to being a substitute for proper lightning protection. Protection against a lightning strike involves low inductance grounds, proper common bonding of all equipment chassis, plus some form of over voltage protection device in the antenna lead. After you do all this, unplug the radio, set it in the corner and perhaps then it would be safe!

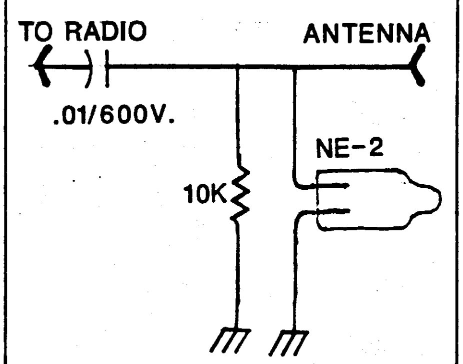
The level of protection I'm talking about is more suitable for those times when a storm comes by suddenly and you've forgotten to unplug or ground your antenna. The storm doesn't even have to look very serious, the weather can be bright out, but under the right conditions a static charge in the thousands of volt range can accumulate on your antenna. What we need is a way to remove the voltage without affecting the RF signals on the same wire.

An inductor placed from the antenna to ground will present a DC path for the static charges and prevent them from building up. The inductor's value is chosen so it presents a high impedance at the lowest frequency the antenna will be used for. The ICOM R-7000 VHF-UHF receiver uses this method, with a small coil placed directly across the input antenna connection.

Many HF receivers use a tiny light bulb in series with the antenna connection. This acts as a fuse, since the filament of the bulb is very thin and easily separated if any significant amount of current passes through it. The filament, if blown, usually physically pulls apart, leaving a fairly large air gap, which may prevent subsequent damage. This fuse is usually followed by a DC blocking capacitor and an inductive path to ground.

Another method, which may be used in conjunction with the above, is to place diodes across the antenna line. The plan here is that the diodes won't conduct until .7 volts is reached, or more if there are several diodes in series. This is a quite popular technique, I recall my shiny new Japan Radio NRD 515 produced garbled local broadcast station audio everywhere as soon as it was connected to my longwire. There was enough RF on the antenna to cause the diodes to conduct and rectify the RF. This will produce a mixing action which results in the signals showing up where they aren't supposed to be. A quick clip of the diode and all was well. However, the protection devices cannot prevent anything if they're not connected. If you have to remove these diodes, it would make sense to replace them with an alternate form of protection.

I can't recall where I first read about putting a neon bulb across the antenna to protect the receiver, but it has been something that has worked very well for me. The bulb, usually a type NE-2 or NE2-H (Radio Shack # 272-1101 or 272-1102) comes with wire pigtails and is best soldered across the input of each radio you have, and across the lead of each antenna. If it is a coaxial lead in, the bulb just goes across the inner and outer conductors. If it is a single wire lead in, or TV type twin lead, one bulb should fitted from each conductor to ground. No external resistor is required or desired for this application. The neon bulb acts like a completely open circuit until its firing voltage, usually about 70 volts, is reached. It then conducts heavily until the voltage drops, and then goes open. Typically, during high static conditions you can see the bulb start to flash as the storm is nearby, increasing to a steady glow as things get closer. One of my antenna switch boxes has a NE-2 mounted so it is visible, as a visual warning that it's about time to think about disconnecting everything! If the glow gets bright enough so that it turns pinkish, look out! Lots of static is being drained off and you are in danger of a very nearby lightning strike. This is the time when it's not smart to disconnect your equipment. You should have done that before! Speaking for myself, I'm not interested in being the one holding the "just disconnected with no place to go but through me" piece of coax, just as the



TYPICAL INSTALLATION

lightning strikes! The neon bulb still allows a 70 volt charge to be built up, although I have never seen a case where this damaged anything, it still is a fairly large potential as far as solid state devices are concerned. A small 10K ohm resistor in parallel with the NE-2, the value isn't at all critical, will serve to bleed off any slowly accumulating static, with the larger surges handled by the neon bulb. A series capacitor, to block any DC voltage, can also be used after the NE-2/10K combination. Any value in the .01 uf to .1 uf range with a voltage rating of several hundred volts would do just fine. It's just one additional small piece of protection.

Nothing about this costs much money. The neon bulbs are common and cheap, easy to install and provide a good level of protection against anything but a very near or direct hit. They are especially useful on DX listening trips with beverage antennae, which are very effective at gathering up static charges! My advice is to install these everywhere you can, and then forget about them. Use commercial lightning arrestor units outdoors, install them properly, and disconnect your equipment whenever prudent. Just perhaps, the time you forget to do all this, these little devices might save your radio!

AUDIO IMPEDANCE TRANSFORMATION BOX

Many older communications receivers made for the military use a 600 ohm audio output. Hooking this directly to a normal 4 or 8 ohm speaker can result in poor audio performance. A proper matching transformer is not an especially common item to find, especially if you are looking for one marked "600 ohms/8 ohms". Fortunately, the audio transformers used in public address and audio distribution systems will do the job just fine. Such a transformer can be purchased from a local Radio Shack store, the part number is 32-1031.

These transformers come with multiple taps on both the inputs and outputs. The output taps are marked as 4, 8 or 16 ohms. Pick whichever matches your speaker impedance, usually 8 ohms. It really isn't that critical. The input taps are marked in various wattages. These are the wattages that will be drawn from the 70 volt audio distribution line and delivered to the speaker. These windings have a specific impedance, not given but easily calculated. In the case of the Radio Shack transformer, I measured the impedance of the 10 watts tap (to the "common" terminal) as being approximately 550 ohms at 1000 hz. Audio response was essentially flat across an 8 ohm load from 100 to well over 10,000 hertz. The 5 watt tap measured nearly 1200 ohms and the 2.5 watt tap measured about 2200 ohms. For most receivers the 10 watt tap would the ideal value. Incidentally, this would apply to any other 70 volt PA type transformer. If it has a 10 watt tap, it will be near 500 or 600 ohms. If you come across a 25 volt type, it can be used as well. Here the 1 watt tap will work out to an impedance of 625 ohms.

$$R = V^2/R = \frac{70.7 \times 70.7}{10} = 500 \text{ ohms}$$

If you do a lot of experimenting with old sets, it might be handy to build a transformer and speaker into a small box, and bring all the primary taps to a jack or a selector switch, and then you'll be well equipped to handle anything!