From telecom@eecs.nwu.edu Wed Aug 7 00:47:09 1991
Received: from hub.eecs.nwu.edu by gaak.LCS.MIT.EDU via TCP with SMTP
        id AA19091; Wed, 7 Aug 91 00:46:57 EDT
Resent-Message-Id: <9108070446.AA19091@gaak.LCS.MIT.EDU>
Received: from trout.nosc.mil by delta.eecs.nwu.edu id aa29672;
          5 Aug 91 8:43 CDT
Received: by trout.nosc.mil (5.59/1.27)
        id AA15410; Mon, 5 Aug 91 06:40:37 PDT
Received: by jartel.info.com (/\=-/\ Smail3.1.18.1 #18.7)
        id <m0k758G-00018IC@jartel.info.com>; Mon, 5 Aug 91 06:38 PDT
Received: by denwa.info.com (5.59/smail2.5) with UUCP
        id AA10327; 5 Aug 91 06:28:44 PDT (Mon)
Received: by denwa.info.com (5.59/smail2.5) with UUCP
        id AA10322; 5 Aug 91 06:28:28 PDT (Mon)
Received: by bongo.info.com (smail2.5)
        id AA04642; 5 Aug 91 06:20:12 PDT (Mon)
Reply-To: julian@bongo.info.com
X-Mailer: Mail User's Shell (6.4 2/14/89)
To: telecom@eecs.nwu.edu
Subject: Phone Patches
Message-Id: <9108050620.AA04638@bongo.info.com>
Date: 5 Aug 91 06:20:06 PDT (Mon)
From: Julian Macassey <julian@bongo.info.com>
Resent-Date: Tue, 6 Aug 91 23:50:11 CDT
Resent-From: telecom@eecs.nwu.edu
Resent-To: ptownson@gaak.LCS.MIT.EDU
Status: RO

Dear Patrick,
Here is an article I wrote about phone patches. If you think it is
worth it, stuff it in the archives.

------cut, slash, deforest ----------------------

BUILDING AND USING PHONE PATCHES

From simple to elegant, patches help make the connection

By

Julian Macassey, N6ARE

First Published in Ham Radio Magazine
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In telephone company parlance, a patch is any connection

between a phone line and another communications device, whether it be a radio, a tape recorder, a data device (such as a modem), or even another phone line.

Radio Amateurs, on the other hand, tend to limit the meaning of "patch" to the connection of transmitters or receivers to the phone line for phone conversations. But there's more to it - Amateurs can and do use phone patches for purposes other than telephone conversations. One particularly effective application is for checking TVI and RFI complaints; simply set the transmitter on VOX, go to the site of the interference complaint, and then key your transmitter via the phone line. Doing this will indicate whether your transmitter is or is not the source of the problem. If it is, you can use this method to test the measures you've taken to correct the problem.

A phone line is, simply speaking, a 600-ohm balanced feed device - which also happens to be how professional audio can be described. Most modern Amateur transmitters have 600-ohm unbalanced inputs; most cassette recorders have a 600-Ohm unbalanced input; the "tape" outputs on home stereos are also 600-ohm unbalanced. All this makes patching relatively simple. While there are various degrees of sophistication and complexity in patching, in an emergency, patches can be easily put together using readily available components. Before starting to build a patch, however, it might be helpful to read last month's article on understanding phone lines.

The Simple Patch

The simplest way to patch a phone line to another piece of equipment is to use a couple of capacitors to block the phone line DC. While this simple approach will work in a pinch, it will tend to introduce hum to the line because of the unbalance introduced. The capacitors used should be nonpolar, at least 2-ohm F, and rated at 250 volts or better (see fig.1).

To hold the line, the patch should provide a DC load by means of a resistor (R6) or by simply leaving a phone off the hook. The receiver output may need a DC load (R7) to prevent the output stage from "motorboating." Use two capacitors to maintain the balance.

With all patches hum can be lessened by reversing the phone wires. A well-made patch will have no discernible hum.

The Basic Phone Patch

Because a phone line is balanced and carries DC as well as an AC signal, a patch should include a DC block, a balun, and a DC load to hold the line. The best component for doing this is a 600-ohm 1:1 transformer such as those used in professional audio and for coupling modem signals to the phone line, available from most electronics supply houses. Old telephone answering machines are also a good source of 600-ohm transformers. Some transformers are rated at 600-900 ohms or 900-900 ohms; these are also acceptable. Make sure that the transformer has a large enough core, because DC current will be flowing through it. (Some small-core transformers become saturated and distort the signal.)

In section 68.304 of the FCC Part 68 regulations, it states that a coupling transformer should withstand a 60 Hz 1kV signal for one minute with less than 10 mA leakage. For casual use this may seem unimportant, but it provides good protection against any destructive high voltage that may come down the phone line, and into the Amateur's equipment. A 130 to 250 volt Metal Oxide Varistor (MOV) across the phone line will provide further protection if needed.

The DC resistance of the transformer winding may be so low that it hogs most of the phone line current. Therefore, while using a phone in parallel for monitoring and dialing - which is recommended - the audio level on the incoming line may be too low. Resistors R1A and R1B (see fig.2) will act as current limiters and allow the DC to flow through the phone where it's needed. If possible, these resistors should be carbon composition types.

To keep the line balanced, use two resistors of the same value and adjust the values by listening to the dial tone on a telephone handset. There should be little or no drop in volume when the patch transformer is switched across the phone line.

One of these transformers, or even two capacitors, can be used to patch two phone lines together, should there be a need to allow two distant parties to converse. There will be losses through the transformer so the audio level will degrade, but with two good connections this will not be a problem.

On the other side of the transformer - which could be called the secondary winding - choose one pin as the ground and attach the shields of the microphone and headphone cables to it. Attach the inner conductors to the other pin. The receiver output will

work well into the 600-ohm winding, and if transmitting simplex or just putting receiver audio on the line there will be no crosstalk or feedback problems. In some cases, the audio amplifier in a receiver does not have enough output to feed the phone line at an adequate level; this can be handled by using the transformer with two secondaries (see the "improved" patch below) or by coupling a 8:1 kilohm transformer between the audio output and 600-ohm transformer. If RF is getting into the transmitter input, a capacitor (C1) across the secondary should help. A good value for the lower bands and AM broadcast interference is 0.1 uF. For higher frequencies, 0.01 uF usually gets rid of the problem. Unshielded transformers are sensitive to hum fields and building any patch into a steel box will help alleviate hum as well as RFI.

The Improved Phone Patch

Several enhancements can be made to the basic phone patch to improve operation. The first is the addition of a double-pole double-throw switch to reverse the polarity of the phone line to reduce hum. This may not be necessary with a patch at the same location with the same equipment, but if it is, experiment with the polarity of the transformer connections and adjust for the least hum. Most of the time the balance will be so good that switching line polarity makes no difference. The switch should have a center "off" position or use a separate double-pole single throw switch to disconnect from the line. The two secondaries on the "improved" patch (fig.3) should be checked for balance by connecting the receiver and transmitter and checking for hum while transmitting and receiving. Switch the shield and inner conductors of the secondaries for minimum hum.

Many transmitters do not offer easy access to the microphone gain control. There may also be too much level from the patch to make adjustment of the transmit level easy. Placing R10 across the transformer allows easy adjustment of the level. It can be set so that when switching from the station microphone to the patch the transmitter microphone gain control does not need to be adjusted. This will also work on the basic 600-ohm 1:1 transformer. Most of the time a 1 kilohm potentiometer - logarithmic if possible - will work well. If not, a linear potentiometer will do. A 2.5kilohm potentiometer may provide better control.

Deluxe Operation and VOX

Using VOX with a phone patch may cause a problem with receive audio going down the line and into the transmit input, triggering the VOX. There may not be enough Anti-VOX adjustment to compensate for this. The usual solution for this problem is to use a hybrid transformer, a special telephone transformer with a phasing network to null out the transmit audio and keep it off the receive line. Most telephones employ a similar transformer and circuit so that callers will not deafen themselves with their own voices. These devices are called "networks" (see figs. 4 and 5).

A network can be removed from an old phone and modified into a deluxe patch, or the phone can be left intact and connections made to the line and handset cords. The line cord should be coupled to a 600-ohm 1:1 transformer to keep the ground off the line. Note, in the network schematics, that the receiver and transmitter have a common connection; when coupling into radios or other unbalanced devices, make this the ground connection.

There may be confusion about terms used in the network. The telephone receiver is receiving the phone line audio, and the transmitter is transmitting the caller's voice. For phone patch use, a telephone receive line is coupled to the transmitter and the transmit line is coupled to the radio receiver. This is a fast way to put together a phone patch and may be adequate for VOX use.

A better patch can be built by using a network removed from a phone or purchased from a local telephone supply house. This approach offers the added advantage of being able to adjust or null the sidetone. The circled letters in figs. 4 and 6 refer to the markings on the network terminal block. These letters are common to all United States networks made by Western Electric (AT & T), ITT, Automatic Electric, Comdial, Stromberg Carlson, and ATC.

To make sidetone adjustable, remove R4 (R5 in European networks) and replace it with R11 (for European networks use R12). The Western Electric Network comes point-to-point wired and sealed in a can; the other networks are mounted on PCBs. To remove R4 from the Western Electric network, the can has to be opened by bending the holding tabs. Don't be surprised to find that the network has been potted in a very sticky, odious paste that has the texture of hot chewing gum and the odor of unwashed shirts. (This material - alleged to be manufactured according to a secret formula - will not wash off with soap and water. The phone company has a solvent for it, but because one of the secret ingredients is said to be beeswax, ordinary beeswax solvents such

as gum turpentine, mineral turpentine (paint thinner or white spirit) and kerosene will work.) To remove the bulk of the potting compound, heat the opened can for 30 minutes in a 300 degree F (148 degree C) oven, or apply heat from a hot hairdryer or heatgun. You can also put the can out in the hot sun under a sheet of glass. Don't use too much heat because the plastic terminal strip may melt. Even with a film of compound remaining on it, the network can be worked on.

Using a Patch

For efficient use, a patch should have a telephone connected in parallel with it. This enables the operator to dial, answer, and monitor calls to and from the patch, as well as use the handset for joining in conversations or giving IDs.

One useful modification to the control telephone is adding a mute switch to the handset transmitter. This allows monitoring calls without letting room noise intrude on the line. It's also a good modification for high noise environments, where ambient noise enters through the handset transmitter and is heard in the receiver, masking the incoming call. Muting the transmitter makes calls surprisingly easy to hear. The mute switch can be a momentary switch used as a "Push-To-Talk" (PTT) or a Single Pole Single Throw (SPST) mounted on the body of the phone for long-term monitoring. The switch should be wired as Normally Closed, so that the transmitter element is muted by shorting across it (see fig.4). This makes the mute "clickless." If the monitor phone uses an electret or dynamic transmitter it should still be wired as shown in fig.4.

Transmit and receive levels on the phone line are a source of confusion that even telephone companies and regulatory agencies tend to be vague about. The levels, which can be measured in various ways, vary. But all phone companies and regulatory agencies aim for the same goals; enough level for intelligibility, but not enough to cause crosstalk. The most trouble-free way to set the outgoing level on the patch is to adjust the feed onto the phone line until it sounds slightly louder than the voice from the distant party on the phone line. If the level out from the patch is not high enough, the distant party will ask for repeats and tend to speak louder to compensate for a "bad line." In this case, adjust the level to the patch until the other party lowers his or her voice. The best way to get a feel for the level needed is to practice monitoring on the handset by feeding a broadcast station down the phone line to another Amateur who can give meaningful signal reports. It's

difficult to send too much level down the phone while monitoring because the signal would simply be too loud to listen to comfortably. The major problem is sending too little signal down the line.

Coupling the phone line into the radio transmitter is not much more difficult than adjusting a microphone to work with a radio transmitter. Depending on the setup, the RF output indication on a wattmeter, the ALC on the transmitter or even listening to the transmitted signal on a monitor receiver will help in adjusting the audio into the radio transmitter. Phone lines can be noisy, and running too much level into the transmitter and relying on the ALC to set the modulation can cause a fair amount of white noise to be transmitted. Watching the RF output while there are no voice or control signals on the line will help in adjusting for this. VOX operation can alleviate the problem of noise being transmitted during speech pauses.

A hybrid patch used for VOX operation needs to be adjusted carefully for good performance. If it has a null adjustment, this should be set before adjusting the VOX controls. Using a separate receiver/transmitter setup is the easiest to adjust the patch. The phone line should be attached to a silent termination: the easiest way to do this is to dial part of a number; another way to do it is call a cooperative friend. Tune the shack receiver to a "talk" broadcast station or use the BFO as a heterodyne. With the transmitter keyed into a dummy load, set the null adjustment potentiometer R11 (R12 for European phones) for a minimum RF output on the transmitter. Using a transceiver, place an oscilloscope or audio voltmeter across the microphone input terminals and, while receiving a signal, adjust for the lowest voltage. For proper operation, it's important that the phone be connected to the patch during these adjustments since the hybrid relies on all inputs and outputs being terminated.

Reference

1. Julian Macassey, N6ARE, "Understanding Telephones," ham radio, September 1985, page 38

Bibliography

Rogers, Tom, You and Your Telephone, Howard W. Sams & Co., Inc., Indianapolis, Indiana 46206. ISBN No. 0-672-21744-9.

Bell System Technical Reference 48005; Telephones, January, 1980.

British Standard Specification for General Requirements for Apparatus for Connection to the British Telecommunications Public Switched Telephone Network. BS 6305.

Certification Standard for Voice-Type Terminal Equipment and Connectors, No.CS-01 and No.CS-03, Department of Communications, Government of Canada.

FCC Rules and Regulations: Part 68 - connection of Terminal Equipment to the Telephone Network, United States Government Printing Office, 1982.

End of Text

Fig 1. Simple Phone Patch

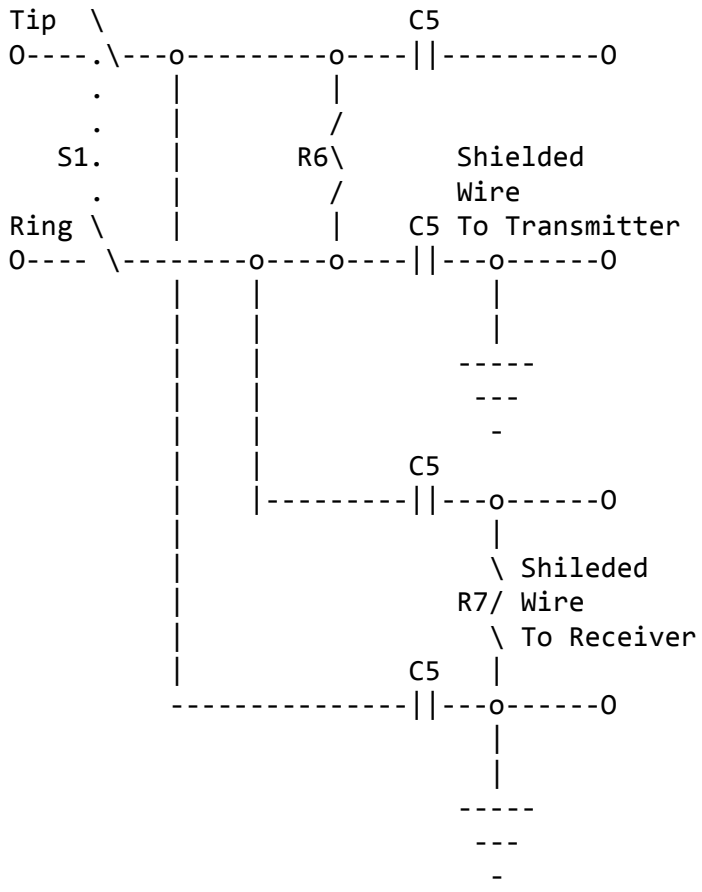


Fig 2. Basic Phone Patch

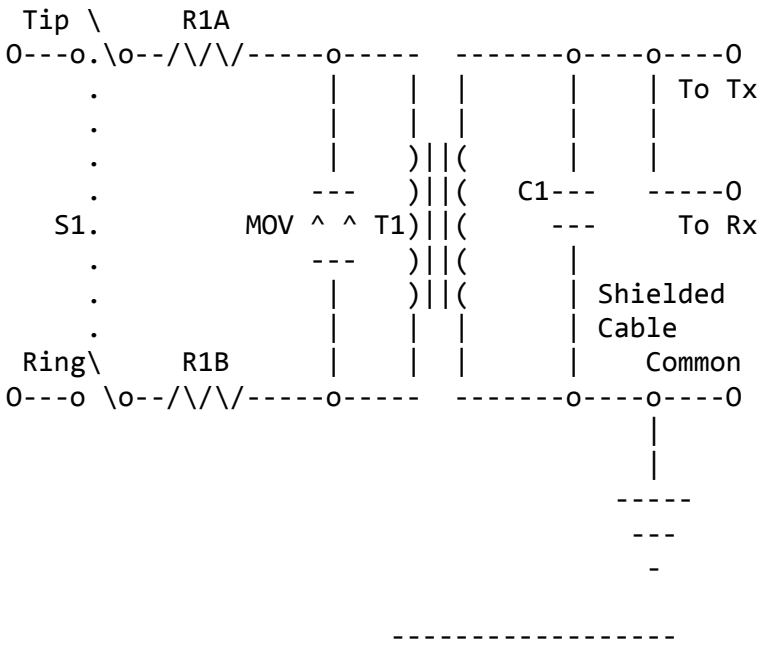
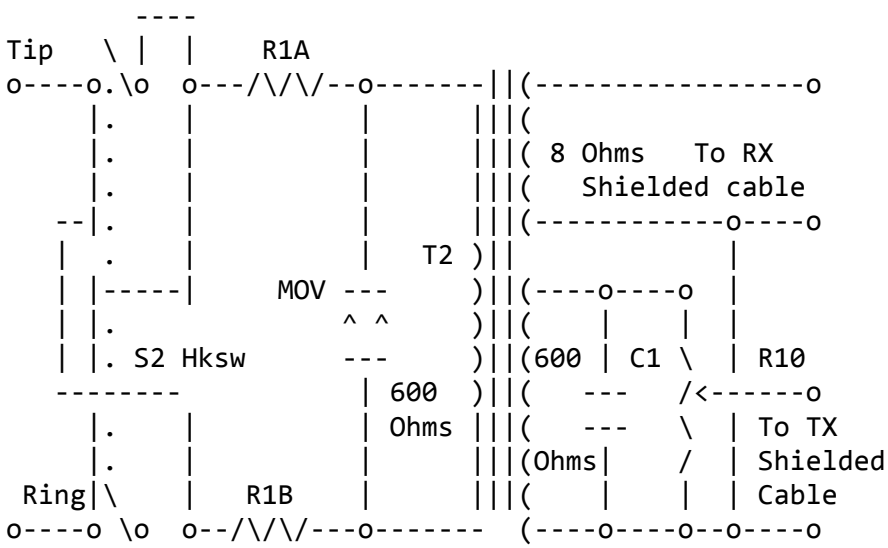
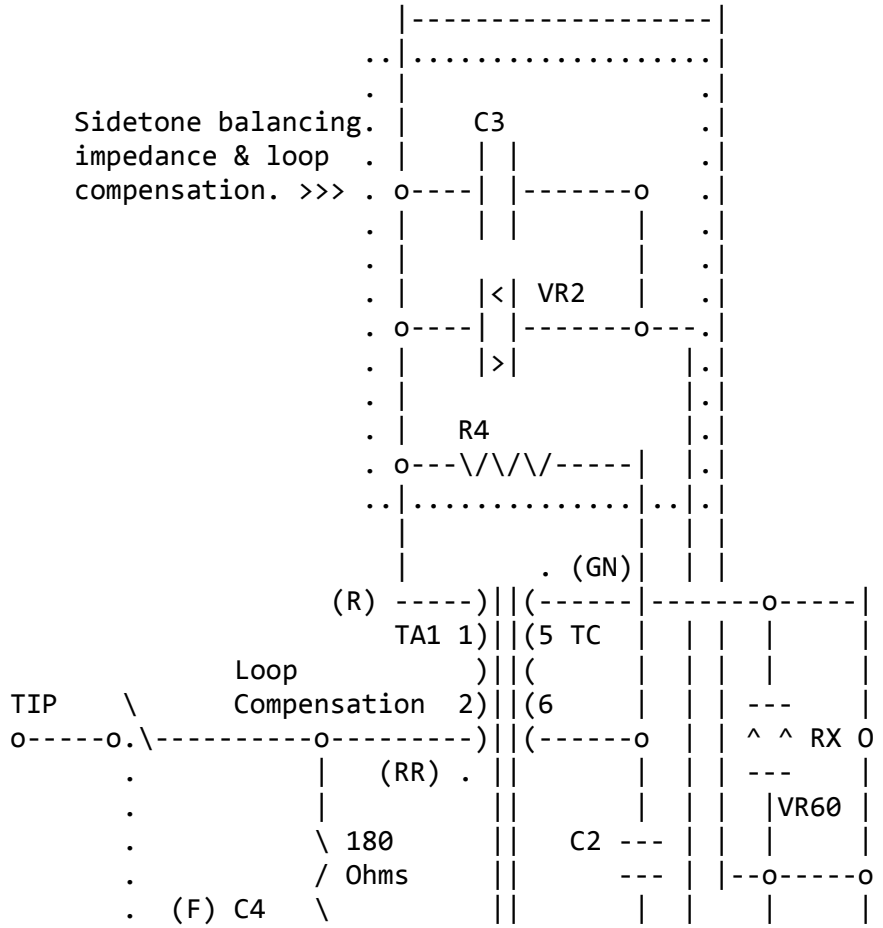


Fig. 3 Improved Phone Patch



NOTE: S2 Hook Switch is also a polarity reversal switch.

Fig 4. Typical U.S. Network (425B). Note: Circled letters are marked on Network Interconnection block terminals. Component values may vary slightly between manufacturers.



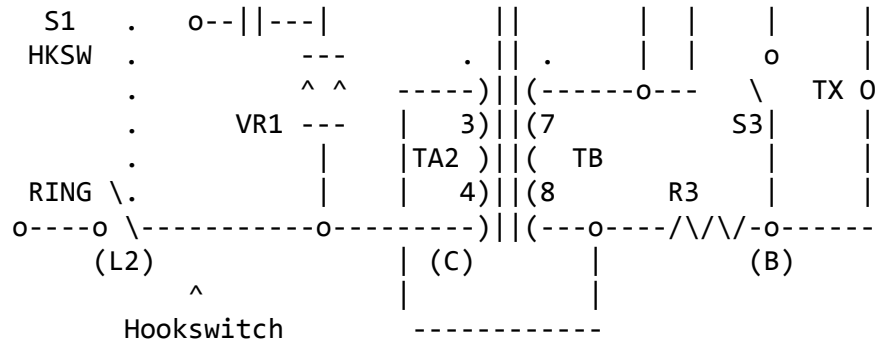


Fig. 5. Typical European Network

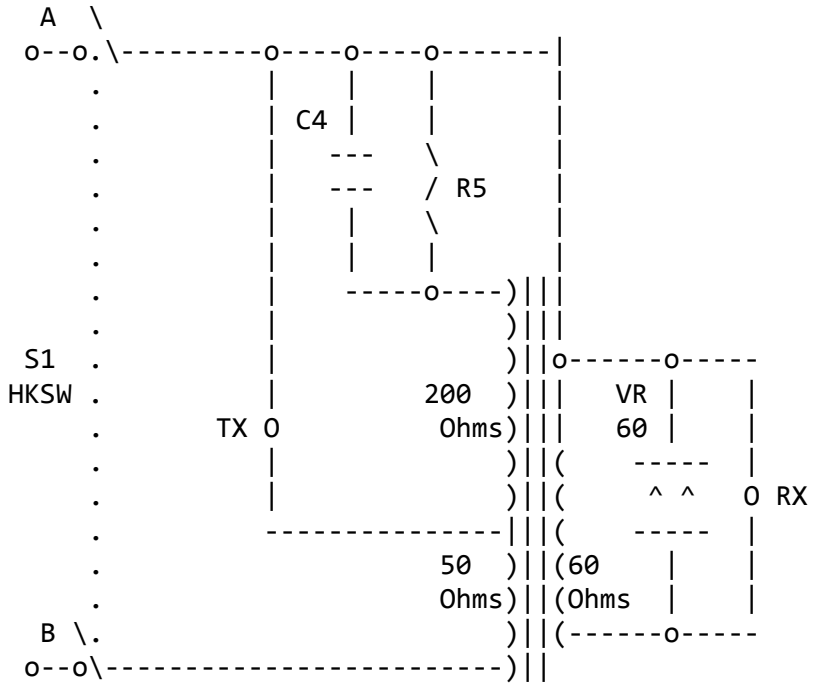
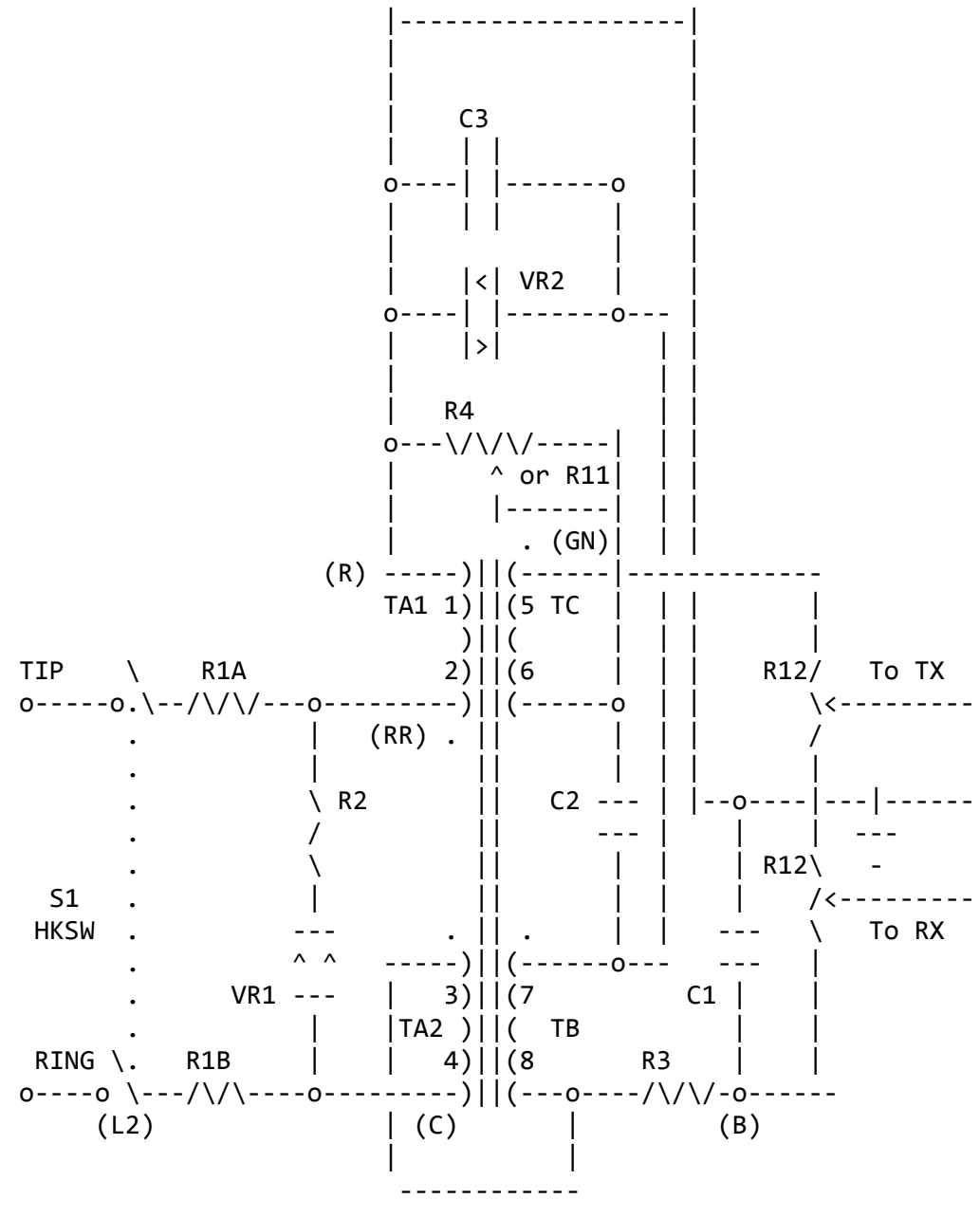


Fig. 6. Deluxe Phone Patch



Note: T1 600 Ohm 1:1 Transformer would be between R1 and the line.

Parts List

Item	Description
C1	0.1 uF (see text)
C2	1.5 to 2.0uF (Depending on manufacturer)
C3	0.47 uF Not used in all networks
C4	0.1 uF
C5	2.0 uF 250 Volt Mylar Film (see text)
MOV	130 to 250 Volt MOV (see text)
R1A,B	100 to 270 Ohms (see text)
R2	180 to 220 Ohms (depending on manufacturer)
R3	22 Ohms
R4	47 to 110 Ohms (depending on manufacturer)
R5	1 Kilo Ohm
R6	1 Kilo Ohm (see text)
R7	10 Ohm (see text)
R10	1 Kilo Ohm potentiometer (see text)
R11	200 Ohm potentiometer (see text)
R12	2 Kilo Ohm potentiometer (see text)
S1	DPST or Hookswitch
S3	NC Momentary switch (see text)
T1	600 Ohm 1:1 transformer
T2	600 Ohm primary. 600 Ohm and 8 Ohm secondary (see text)
T3	Network Transformer
VR1	Silicon Carbide Varistor or Back-to-back Zener
VR2	Silicon Carbide Varistor or Back-to-back Zener
VR60	Silicon Carbide Varistor or Back-to-back Zener

END

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