Heathkit of the Month #31:
by Bob Eckweiler, AF6C

Heathkit HD-15
Hybrid Phone-Patch

Introduction:

Does anyone phone-patch anymore? In the sixties and seventies when you tuned across the band you would inevitably hear hams running phone-patches. The proliferation of cell phones and unlimited calling plans is likely why they have all but disappeared from ham radio.

A phone-patch allows a ham to connect his radio to the standard telephone 'POTS' line and let someone at the other end of the phone-line communicate with the person at the other end of the radio link; often this was used for third-party traffic. Phone-patches can be run between third parties in the US, and also to people in a limited number of countries that have third party agreements with the US.

Phone-patches were once very common. I built my first phone patch when I was barely a teenager. It used a popular war-surplus Lionel audio interstage transformer (yes, the same Lionel that makes electric trains).

Figure 1: HD-15 Front & Rear View

During the seventies I ran numerous phone-patches for a neighbor who's husband was working in South America. I also had the honor of running phone-patches between Bill Orr - W6SAI, who was on vacation in Hawaii at the time, and a family member who was living in southern Orange County. I got to visit Bill some years later in Northern California. For those who don't know W6SAI, he is the author of numerous ham articles and antenna books, as well as the *Radio Handbook*. Sadly, Bill became a silent key not too long ago.

The Hybrid Phone-Patch:

Simple phone-patches, like the one I built early on, use an audio transformer to couple the 600Ω phone-line to the 8Ω speaker and the high-impedance microphone input. Audio from the speaker is transformed to 600 ohms and merrily travels down the phone-line to the user at the other end. Likewise, audio from the phone-line is converted to high impedance and is sent to the transmitter mike input. However, audio from the receiver speaker is also sent to the mike input. If manual switching is used between transmit and receive, this presents no problem. But when the era of single-sideband began and made VOX operation popular, audio from the speaker would trigger the VOX making VOX phone-patch operation impossible.

This problem was solved by using a hybrid bridge circuit that effectively nulls-out the audio from the speaker at the transmitter mic input while letting audio from the phone-line pass. This requires a special transformer and a nulling circuit.

Heathkit Phone Patches:

Heath made many phone patches during its kit-building existence. They are:

Model	Description	From:	To:	Initial Cost:
HD-19	Hybrid Patch	1960	1965	$29.95
HD-15	Hybrid Patch	1966	1983	$24.95
SB-630	Station Console	1966	1974	$74.95
SB-634	Station Console	1974	1983	$179.95
HD-1515	Solid-State Patch	1985	1989	$49.95

Figure 2: The HD-19 From a 1961 Heathkit Catalog

The two station consoles not only include a hybrid phone-patch but also numerous station accessories all in one package. While this month the focus will be on the HD-15, we will take a quick look at the others too.

The Heath HD-19 Phone-Patch:

Heath's first phone patch presented a clue as to what was to come. It is one of the first kits to sport the dark green front panel color of the upcoming SB-line. The HD-19 (Fig. 2) circuit is almost identical to the HD-15 which will be discussed next. It differs in that it includes switching for a high impedance microphone. The microphone is connected to the HD-19 and a cable from the rear of the HD-19 connects to the microphone input of the transmitter. When the patch is not in use the microphone is connected to the transmitter and when the patch is turned on the microphone is disconnected and the phone patch is connected to the transmitter. There are also minor circuit variation between the HD-19 and later HD-15. The HD-19 case measures 7-3/8" W x 4-1/8" H x 4" D.

The Heath HD-15 Hybrid Phone-Patch:

The HD-15 is one of many items manufactured by Heath during the existence of the SB-line that didn't carry the SB prefix, but followed the SB styling. It is enclosed in a low-profile case measuring 9-1/4" W x 2-5/8" H x 3-5/8" D. The front panel incorporates a VU meter and three controls.

The VU (Volume Units) meter monitors the energy being put onto the phone-line; too much and you will create cross-talk which may invoke a visit from the "Phone Police". The gain controls set the operating levels. The receive level can be monitored by the VU meter and the transmit level by the transmitter's ALC meter reading.

Item	Type	Marking
VU	Meter	-20dB to +3dB
XMTR. GAIN	Pot	0 - 10
RCVR. GAIN	Pot	0 - 10
PATCH	Switch, Rotary	OFF - ON

The rear panel contains a five-screw-terminal connector for the two-wire phone line, the speaker lead, receiver audio and their common ground. Two RCA jacks provide audio to the transmitter. Available are high impedance audio and 600-ohm audio. A control for nulling the balance circuit and a meter switch are also located on the back panel:

Item	Type	Marking
(Meter Function)	Slide Switch	NULL - MONITOR
(Xmtr audio)	RCA Jack	HI-Z
(Xmtr audio)	RCA Jack	600Ω
NULL - ADJUST	Pot	(none)
(Terminal Strip)	Screw Term. 1	GND [audio]
I	Screw Term. 2	SPKR [audio]
I	Screw Term. 3	RVCR [audio]
I	Screw Term. 4	[phone] LINE
(Terminal Strip)	Screw Term. 5	[phone] LINE

The only adjustment to the HD-15 is the nulling of the balance circuit. This is accomplished after fully connecting the patch by placing the meter switch on the rear panel to NULL and then tuning the receiver to a strong heterodyne (you can use the crystal calibrator of the receiver) so a steady tone is coming from the receiver. With the phone-patch switched on advance the receiver volume and patch RCVR. GAIN control until you get a deflection on the meter of about 0 dB. Adjust the NULL control on the back until the meter reads minimum. You should be able to get a null of between 20 and 30 dB on the meter. This represents the isolation between the receiver audio and the transmitter audio.

Operating the phone-patch is quite simple. A phone call is established between you and the third party. If the third party is not familiar with using a phone-patch, they need to be briefed on the basic FCC rules and to remember to say "over" when they are done talking. They also need to be briefed on how VOX works if it is to be used. (I've found that unless the third party is experienced, they will continually try to interrupt when the distant station is transmitting - so I usually manually switched between transmit and receive.) Once briefed you need only to switch on the phone-patch and monitor on your phone handset. Some hams who ran phone-patches frequently used telephone operator headsets to monitor.

The HD-15 Circuit:

The schematic of the HD-15 is shown in Figure 3; it is very straightforward. The phone-line is connected through a pi-filter (the two 45 µH coils and C1 - C4) to isolate any RF present. C5 DC isolates the phone-line so it will not create

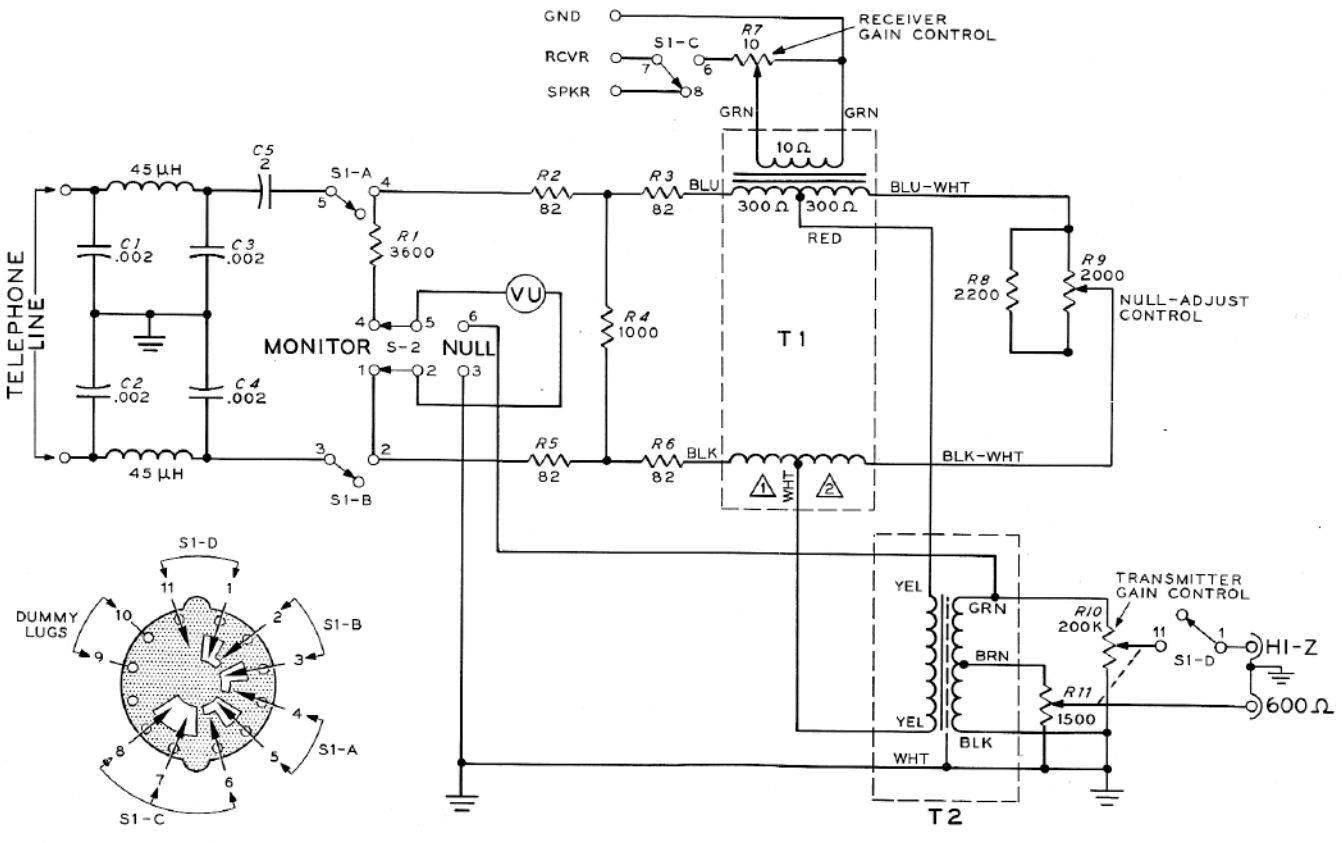

Figure: 3

an "off-hook" condition when the patch is on. S1a and S1b isolate the phone-line when the patch is off. In monitor mode the VU meter monitors the level entering the phone-line. A VU of 0 dB (About 2/3 of the meter movement) represents 2.25 milliwatts into the phone-line (1.23V at 600Ω). This is the maximum allowed signal. R1 sets the calibration of the VU meter.

The null circuit is made up of T1, a special hybrid transformer and R9. In transmit, audio voltage entering from the phone-line appears on both the primary of T1 and the secondary of T2. Each is attenuated by 6dB. The audio on the secondary of T1 is not useful and is harmlessly dissipated in R7 and in the receiver; the audio reaching T2 is transformed to a high impedance output and to 600Ω output; both are available on the rear panel depending on transmitter audio requirement.

On receive the audio from the receiver is coupled to the secondary of T1. This creates a voltage V_1 across each of the two 300Ω primary windings. These voltages are equal and in phase. The voltage from the left winding appears across the phone-line and the left lower isolated transformer winding. The voltage from the right winding appears across the balance pot (R9) and the right lower transformer winding Since the two lower windings are identical and wound on the same core, their voltages V_2 are also identical and in phase. The voltage reaching the microphone appears between the red and white leads (the center taps of the upper and lower windings). The voltage contributed by the left loop is: $+ V_1 + V_{PL} + V_2$. The voltage contributed by the right loop is: $-V_1 - V_{BC} - V_2$. Since the V1 and the V2 are of opposite sign they cancel and $V_{xmtr} = V_{PL} - V_{BC}$. If the balance circuit is adjusted to the same impedance as the phone-line then the currents i_1 and i_2 are also identical and $V_{PL} = V_{BC}$. This means no signal from the speaker audio reaches the microphone input.

You may wonder about three things. First, what is the purpose of R8 across R9. This just changes the linearity of R9 to make the resistance change more slowly near the middle of the pot setting and make nulling more easy (On the original HD-19 just a 1 KΩ pot was used.) Second, what are the two lower windings used for in the transformer? These keep the phone line balanced thus reducing the chance of hum on the phone-line. Finally, what do R2 through R6 do in the phone line circuit? They are actually quite critical. They form a 600 Ω attenuation pad that isolates the impedance of the phone-line from the hybrid transformer. Phone-line impedances vary around the 600 Ω ideal and the pad provides isolation to make the phone impedance look more stable to the transformer and reduce any reactive component; this is at the cost of signal loss. Luckily the receiver audio, phone audio input and output and transmitter audio needs are all sufficient that the loss still allows ample signal levels.

S1-c switches the audio from the speaker to the secondary of T1 when the phone-patch is on

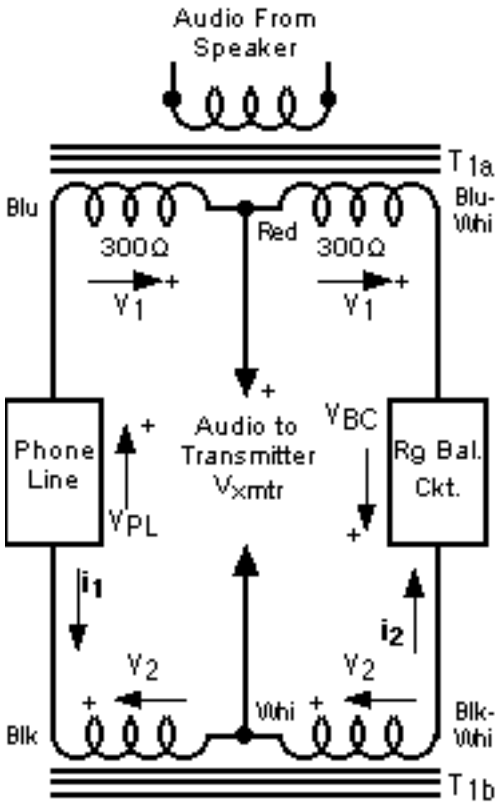

Figure 4: Transmit Null Circuit

and S1-d disconnects the high impedance mic input from the transmitter when the phone-patch is off, since it could shunt the mic causing low transmit audio.

The HD-15 is specifically designed to work with the SB-line of transmitters and transceivers. Both have an input in the back for high impedance phone-patch audio. the lower 600Ω impedance available at the phone patch output allows the HD-15 to work with numerous other rigs of the day (and most of today's radios too).

The Heath SB-640 Station Console's Patch:
The SB-640 station console was discussed briefly last month. Built into it is the identical circuit to the HD-15 except for changes needed to integrate the other functions (meter switching is one example since the meter is used not only with the phone-patch, but also with the SWR bridge.)

The Heath SB-634 Station Console's Patch:
Like the SB-640, the SB-634 also has a built-in phone patch based on the circuit of the HD-15. However, it does have one interesting and historical change. A trap filter was added to the phone-line to attenuate any 2,600 Hz tones that might come from the receiver and enter the phone-line. The SB-634 came out not too long after the phone-phreaking and blue-box era. In those days a tone at 2,600 Hz could be used to cause a long-distance disconnect and leave a phone connection open in the trunk. From there, using the proper tone signaling codes, a hacker was able to dial any number worldwide without charge. When using a phone-patch there is always the possibility of a heterodyne occurring and causing a 2,600 Hz tone being sent into the phone line. The trap helps prevent the tone from getting back to the phone company's central office.

The Heath HD-1515 Solid-State Phone Patch:
The last phone-patch kit manufactured by Heath was the HD-1515. It is significantly different in design and operation from the earlier patches. The HD-1515 is based on the Texas Instruments TCM-1705 Phone Set Integrated Speech Circuit IC, which, along with an LM-324 quad-operational amplifier and four transistors provides the necessary hybrid features without the need for an expensive hybrid transformer. All the other phone-patches mentioned in this article are passive devices; they do not need a source of power to operate other than the signals themselves. This is not the case with the HD-1515 since power is needed to operate the solid-state devices. A typical phone-line has about 48 VDC across it when on-hook. Off-hook (the phone picked up from the cradle) the voltage can vary depending on distance from the central office and number of phones in use. Also the polarity can flip, and the voltage can drop to zero during pulse dialing. Heath cleverly designed a circuit that harnesses power from the phone line to operate the patch. If used on distant lines though, the line voltage may not be sufficient to operate the phone, so Heath also included a standard 9V battery that may be optionally installed should the line voltage be insufficient to operate the phone-patch.

I purchased my HD-15 the the local Ball Rd. Heathkit store on June 14, 1969 (exactly 42 years later to the day I started this article - what a coincidence!). It replaced the home-brew patch that I got rid of before leaving for college (I did keep the Lionel transformer!). Over the next decade I handled hundreds of phone patches on the HF bands, with only a few minor incidents, but many a happy "thank you". It was a rewarding part of ham radio.

73, from AF6C

Remember if you come across any old Heathkit Manuals or Catalogs that you do not need, please pass them along to me.
Thanks - AF6C

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