

Vintage Radio

By Ian Batty



The Westinghouse H-618 6-transistor radio



Released in 1957, Westinghouse's H-618 transistor radio employs a fairly standard circuit design but has its own contemporary styling. Unlike many sets of the era, it uses a transistor as a Class-B demodulator, rather than a conventional diode detector.

It's America in the 1860s. Railways are crossing the country, opening up the vast continent. The West is reached by travelling over the lofty Rocky Mountains. Going up is manageable if slow but coming down the inclines is a different matter, with perhaps hundreds of tons pushing a train forward with ever-increasing speed.

Engineers solve the problem by adding brake vans – rolling stock fitted out with manually-operated brake shoes bearing on the wheels. Brakemen are forced to run across the roofs from one van to another, applying or reducing the brakes as needed.

Engineer George Westinghouse gets his first big break in 1868 when he

invents and patents a braking mechanism using compressed air. This allows individual brake mechanisms to couple into a master system.

Thomas Edison, having invented and marketed the light bulb, set up his direct-current electrical distribution system in 1882. However, DC's drawbacks prompted Westinghouse to explore alternating current (AC). The "War of The Currents" took off, with AC eventually gaining the upper hand following Nikola Tesla's invention of the polyphase induction motor in 1883 and the production of a full working model by 1888. It's still the preferred design for electric motors rated in the kilowatts to megawatts range.

From those early years, Westinghouse Corporation expanded rapidly into the giant that it is today. It's now involved in everything from kitchen appliances to nuclear power systems and jet engines.

The Westinghouse H-618

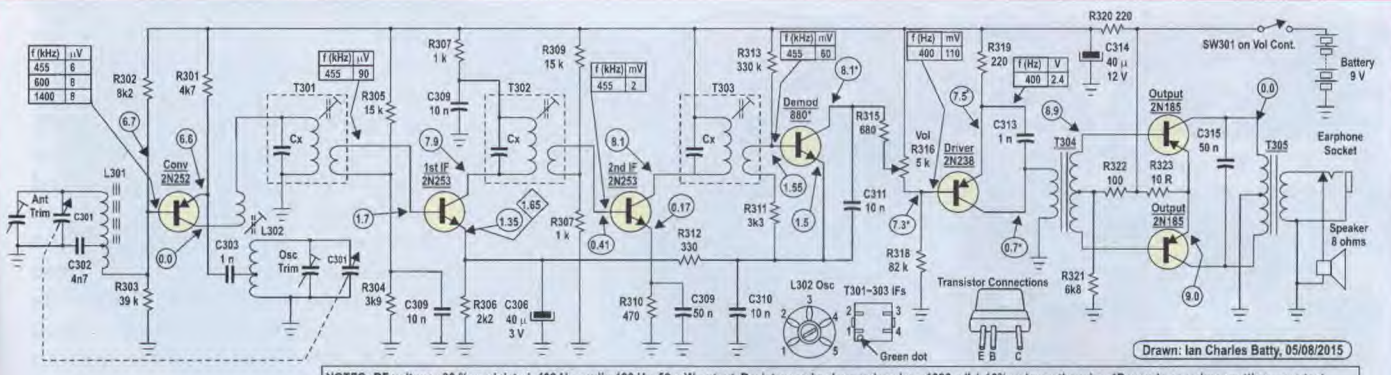
Westinghouse's involvement in semiconductors, like that of Western Electric and General Electric, took off during the 1940s. During that time, the company was involved in researching and supplying diode mixers for war-time radar equipment. When Bell Labs subsequently invented the transistor in 1947, Westinghouse joined other manufacturers in the race to produce working, marketable devices.

One of Westinghouse's early transistor radios was the H-618 which was released in 1957. In contrast to contemporary GE designs, Westinghouse opted for the "standard six" configuration but added a Class-B demodulator instead of using a conventional diode. As a result, the H-618 is really a 7-transistor radio.

While diode demodulators work just fine, they create as much as 20dB signal loss. Considering the moderate added cost of one transistor, Westinghouse's design makes good sense given the improvement in performance. It also meant that the set could be marketed as having seven transistors rather than "only six".

Another advantage of the H-618 is that it's a 9V set and runs from a single battery. It sets aside the oddball voltages and tapings used in other, early transistor sets.

Given its size, it's obviously not a "shirt-pocket" set, especially as it also needs to be operated "right-way-up" rather than vertically because of its horizontal ferrite rod antenna. Visually, it's very much a 1950s/60s design. The font used for the tuning dial, its arched top, lightly "keystoned" sides and arrow-head speaker grille all give it the stamp of "modernity" that characterised this era.



NOTES: RF voltages 30% modulated, 400 Hz, audio 400 Hz, 50 mW output. Resistances in ohms unless k = x1000, all ± 10% unless otherwise. *Depends on volume setting – see text. Capacitances: whole numbers/ p = picofarads, n = nanofarads, μ = microfarads. DC voltages with VTVM, no signal, thus ○ except max signal thus ◇ RF/Audio signal injections □

Fig.1: the Westinghouse H-618 is a 7-transistor superhet design, with a self-oscillating converter and two IF amplifier stages. A type 880 transistor is used as a Class-B demodulator (detector). This feeds a 2N238 audio driver and this stage in turn drives a push-push output stage (2 x 2N185) via phase-splitter transformer T304.

It makes a fine contrast to the stark, minimalist styling of the Regency TR-1. It even has an attractive light mother-of-pearl effect on the white tuning dial background.

TI transistors

One interesting design aspect of the H-618 is that the transistors were all made by Texas Instruments (or, at least, they were in the set pictured here). In fact, beginning with the first transistor portable (Regency’s TR-1), TI transistors dominated early designs.

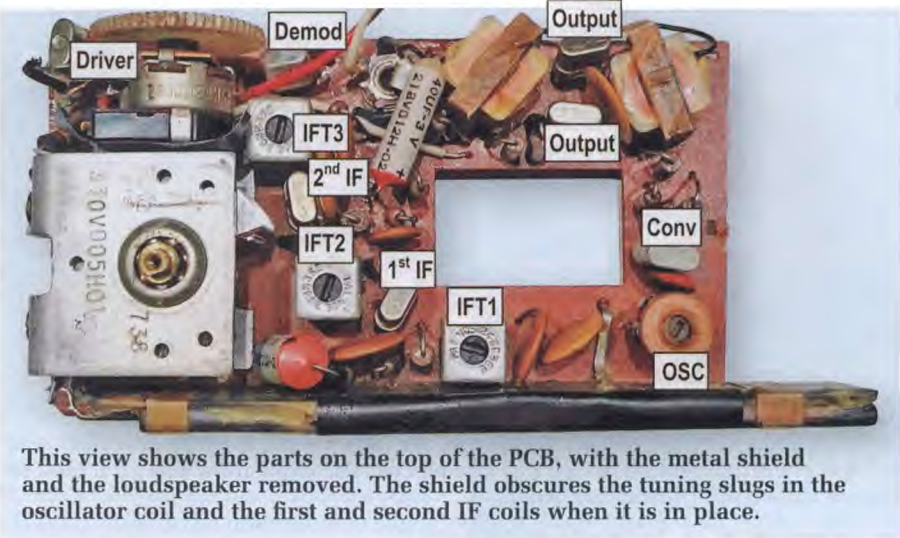
The tuning gang used in the set pictured here carries a “738” stamping and this places the set’s production in the latter part of 1957. This is further confirmed by a “57” serial number on the loudspeaker.

Being an American set of the 1950s, it also carries the CONELRAD station markings. These markings consist of two small red arrowheads on the lower dial section, plus an arrowhead in red circle on the dial knob. During an emergency, tuning the red circle to one of the arrows would bring in a CONELRAD station.

So what was CONELRAD? Basically, it stood for CONTROL of ELECTRONIC RADIATION and was a system that, in the event of a nuclear attack on the US, would close down all television and FM radio stations. Some remaining AM stations would then broadcast information on 640kHz or 1240kHz in a “round robin” roster to frustrate any enemy attempts to use radio direction finding. CONELRAD was decommissioned in 1963.

Circuit description

This set uses a mix of NPN and PNP



This view shows the parts on the top of the PCB, with the metal shield and the loudspeaker removed. The shield obscures the tuning slugs in the oscillator coil and the first and second IF coils when it is in place.

transistors (all from Texas Instruments) in the classic TO-22 can. It’s common to see NPN transistors in the RF/IF section, due to their superior RF performance, and lower-cost PNPs in the audio stages where their poor high-frequency response isn’t a drawback.

Unusually though, the H-618 uses the PNP 2N252 as a converter.

Fig.1 shows the circuit details. The incoming RF signal is picked up by a ferrite-rod antenna and fed to a self-oscillating converter stage which uses emitter injection. The only unusual point is that the antenna coil is connected directly to the transistor’s base, with the blocking capacitor (C302) between the rod’s ground tapping and circuit ground.

This stage, like almost all self-oscillating converters, uses fixed bias. Its collector output feeds the untapped, tuned primary of T301, the first IF transformer.

T301’s untapped, untuned second-

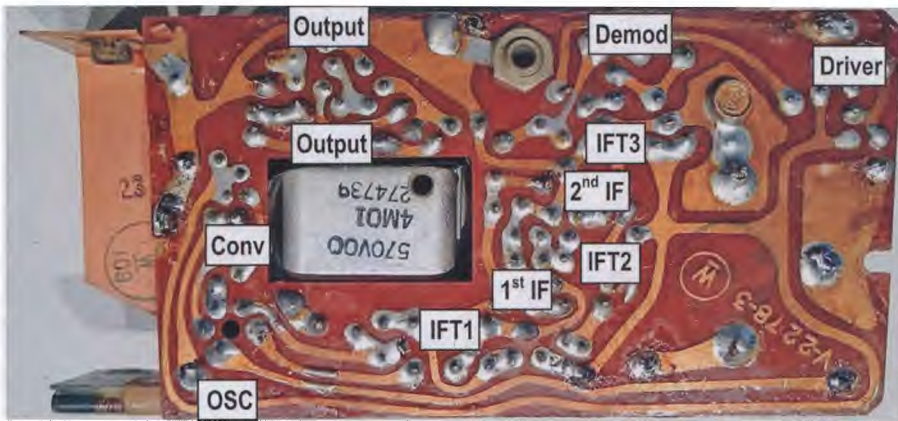
ary feeds the base of the first IF amplifier transistor, a 2N253. This stage is not neutralised and feeds the untapped, tuned primary of T302, the second IF transformer. The stage is also subject to AGC (automatic gain control), as fed back from the demodulator. Its emitter is bypassed using electrolytic capacitor C306 but electrolytics really are a “no-no” at radio frequencies (RF). Indeed, this set wasn’t working properly because C306 had deteriorated, as detailed later.

As shown on Fig.1, the AGC voltage is applied to the first IF amplifier’s emitter, with its base voltage fixed by resistive divider R305 & R304. This is a somewhat unusual arrangement.

The second IF amplifier (another 2N253) is fed from the untapped, untuned secondary of T302. This stage works with fixed combination bias and like the first stage, is not neutralised. Its collector feeds the tuned, untapped primary of T303,



Above is another view of the top of the PCB, this time without the component labels. The layout is quite compact but the parts are all easily accessible once the metal shield and loudspeaker have been removed.



An underside view of the PCB. Despite its age (58+ years), the PCB assembly was in good condition and replacing just two electrolytic capacitors was all it took to restore the set to full working order.

the third IF transformer, and T303's secondary in turn feeds the demodulator.

Demodulator

The demodulator also uses an NPN transistor, either a type 880 or a 2N94 (as in the set featured here). This stage has minimal forward bias applied; just 50mV, in fact. This weak forward bias allows the transistor to respond to the incoming IF signal from T303's untuned secondary, so that it acts as a rectifier.

The demodulator fills two roles. First, it rectifies the incoming IF signal which is then filtered by 10nF capacitor C311 to recover the audio component. This audio signal is then fed to volume control R316 via resistor R315.

The inclusion of R315 may seem odd at first glance, since it reduces the audio signal level to some extent. However, it's necessary to provide a minimum load for the demodulator

when the volume is turned all the way down (ie, when the wiper goes to the positive supply rail). Conversely, as the volume is turned up, the first audio stage (a 2N238) loads the demodulator more and more.

Without resistor R315, audio distortion would become noticeable as the volume was wound down and the load dropped below a certain value. R315 prevents this and because the demodulator also gives useful audio gain, the loss across R315 is tolerable.

Depending on its setting, the volume control also provides load resistance for the demodulator and acts as an attenuator for the signal going to the audio driver stage. The net effect at low volume settings is low gain (due to a low load impedance) coupled with high attenuation. As the volume control is advanced, the demodulator's load resistance increases and the attenuation is reduced, so the overall gain increases.

The demodulator also responds to

increasing IF signals by increasing its collector current. It shares an emitter resistor (R306) with the first IF amplifier and that stage has a very tightly-controlled base voltage which provides the usual forward bias of around 200mV under no signal conditions.

In operation, it doesn't take too much demodulator current to increase the voltage across R306 and slash the first IF amplifier's forward bias. Even 50µA of extra demodulator current will increase R306's voltage drop (and thus reduce bias) by some 100mV; enough to drive the first IF stage towards cut-off.

Changes in the demodulator's collector current (due to signal strength) and the setting of the volume control both influence the audio driver's bias to some extent. The most significant change is the driver's collector voltage, dropping from 0.7V at full volume to 0.26V at minimum volume.

The audio driver stage (2N238) operates with combination bias (volume control R316) and unbypassed emitter resistor R319. This part of the circuit looks to be "upside down" but that's simply because the 2N238 is a PNP device.

Typically, the output from the demodulator will be around 110mV, so there is significant audio gain in the Class-B demodulator. Because of this, the audio driver's emitter resistor is unbypassed, thereby significantly reducing the gain of this stage to prevent overload. By comparison, a diode demodulator would deliver no more than about 10mV of audio.

The audio driver feeds a conventional Class-B push-pull output stage via phase-splitting transformer T304. The output stage uses the popular 2N185 transistors, with fixed bias provided via divider resistors R321 & R322. The service notes stipulate that these transistors must be a matched pair.

The collectors of these transistors then drive the loudspeaker via centre-tapped output transformer T305. Note that the emitters of the 2N185 transistors connect to the positive supply rail via shared emitter resistor R323, while output transformer T305's centre tap goes to ground.

Cleaning it up

As it came to me, the set was in good cosmetic condition and just needed a clean and polish to bring it up nicely.



The set was available in grey, black and red, each with a different model number: 617 (grey), 618 (black) and 619 (red). All three versions use the same circuit.

However, applying power resulted only in loud, uncontrollable squealing. At least the audio stages were working but where was this crazy feedback (oscillation) coming from?

At that stage, I recalled my experience with the Regency TR-1. It had been pretty well dead when I got it and I'd suspected faulty coupling and bypass capacitors in the audio section. Replacing dried-out electrolytics in the audio section had subsequently created a very similar oscillation noise to what I was now hearing.

The Westinghouse H-618 is unusual in that it employs only two electrolytic capacitors: (1) power supply decoupling capacitor C314; and (2) first IF stage emitter bypass capacitor C306 (just like the TR-1). Replacing both electrolytics returned the set to normal operation and I now had a well-performing radio.

As in the GE 675 (SILICON CHIP, September 2015), this set uses a metal plate to cover most of the component side. This plate is secured by twisted lugs and one soldered connection to the PCB. It supports the loudspeaker and also provides a degree of shielding to ensure stability in a set that isn't neutralised.

Unfortunately, it also obscures the adjustment slugs for the local oscillator coil and the first and second IF transformers. While it's possible to remove the cover (as I did for this article), it would be preferable to leave it undisturbed in a set that's working correctly.

The ferrite rod antenna is connected to the PCB via metal straps rather than via thin wires (as in other sets). These straps not only make the connections more reliable but also support the ferrite rod on the PCB.

How good is it?

The H-618 is a mature "standard six" design, so it should be a good performer. Its sensitivity is specified as $200\mu\text{V}/\text{m}$ or better, while the audio output is listed as 100mW or more.

So how does it stack up in practice? The measured RF sensitivity is $150\mu\text{V}/\text{m}$ at 600kHz and 1400kHz for 50mW output, with signal-to-noise (S/N) ratios of 12dB and 10dB respectively. For the usual 20dB S/N ratio, the RF sensitivity is $250\mu\text{V}/\text{m}$ at 600kHz and $300\mu\text{V}/\text{m}$ at 1400kHz.

The IF selectivity is $\pm 4.5\text{kHz}$ at -3dB and $\pm 52\text{kHz}$ at -60dB which is quite respectable. The AGC response is also



These two photos show the moulded plastic case lugs that are used to help secure the loudspeaker (left) and the chassis (above) – see panel.

Special Precautions

The Beitman service sheets recommend monitoring the current drain under test, probably due to concerns about self-heating in the output transistors. In my case, testing at 50mW output did not see the current drain skyrocket but I recommend that you initially follow this advice so that you don't risk destroying these devices.

Also, be aware that the set's chassis is held into the case by a lug next to the speaker (near the control cut-outs) and by a second lug for the speaker's sub-chassis at the end of the battery compartment. There's also a securing screw.

To remove the chassis, first remove the screw, then slide the metal shield out from under the lug at the battery end. The chassis can then be pulled out end-wise. Conversely, to replace it, slide the chassis in and engage it under the speaker lug, then slide the shield under the lug at the battery end. Above all, be careful and take it slowly.

respectable, with a 40dB signal increase resulting in just a 6dB increase in the audio output. It goes into overload for RF signals at around 80mV/m but that's a pretty strong signal.

The audio frequency response from antenna to loudspeaker is 250Hz to 3.4kHz, which is about what you'd expect. From the volume control to the loudspeaker terminals, it's 280Hz to 180kHz at -3dB, making this yet another set where the high-frequency audio response massively exceeds what's possible overall. It's worth noting that the audio response also shows a rise of around 6dB at 1kHz.

The total harmonic distortion (THD) is about 5.8% at 50mW output, falling to about 5.5% at 10mW. The set begins to clip at 110mW output, at which

point the THD is around 7%.

Finally, when the battery voltage is down to 4.5V, there's quite visible crossover distortion in the waveform and the H-618 manages to produce an output of just 18mW before going into clipping. Such low-battery distortion confirms the superiority of diode-biased sets, such as Sony's TR-63 (SILICON CHIP, January 2016) and Pye's Jetliner (SILICON CHIP, September 2014).

Would I buy another?

So would I buy another H-618 if the opportunity arose? I just might; the red version (model H-619), with a black tuning escutcheon, is a stand-out design. There's a photo of it on Ernst Erb's Radio Museum website:

www.radiomuseum.org/r/westinghouse_h_619p7_h619_p7_ch_v_2278.html

In the meantime, I'm enjoying the set described here. Its contemporary design is growing on me and it's a pretty good performer.

In fact, it's one of those sets that seems to get passed over a bit too easily. You might consider adding one to your collection.

Different versions

Finally, it's worth noting that the set came in three different-coloured cases and each had a different model number. These model numbers are: 617 (grey), 618 (black) and 619 (red).

Further reading

(1) The only schematic I could find was a less-than-optimal copy on Ernst Erb's site: www.radiomuseum.org/r/westinghouse_h_618p7_h618_p7_ch_v_2278.html

(2) Beitman circuit books (from 1938 to 1967-69) are available from: <http://makearadio.com/beitmans/>

(3) Information on early Westinghouse power transistors is at: www.semiconductormuseum.com/Transistors/LectureHall/JoeKnight/Joe-Knight_EarlyPowerTransistorHistory_Westinghouse_Index.htm

(4) There's a link to Riders manuals (big PDFs) at www.makearadio.com (thanks to Dave Schmardeer). **SC**