Heathkit of the Month #38
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Heathkit

Heathkit CS-1
Condenser Substitution Box

Introduction:
In November of last year (#35) the Heathkit RS-1 Resistor Substitution Box was discussed. It is a handy piece of test equipment that allows you to temporarily replace a resistor during troubleshooting.

Heathkit made capacitor substitution boxes as well as resistor substitution boxes. One of the boxes is the CS-1 which was passed along to me by the late WA6PFA - Tom last year along with the RS-1. It has already paid me dividends troubleshooting an old (1947 era) National NC-173 receiver.

Prior to the mid-sixties "capacitors" were known as "condensers". The name change occurred because engineers and scientists decided that "capacitor" was more descriptive;

Capacitor Substitution Boxes

Model:	From:	To:
CS-1	1954	1962
IN-22	1962	1967
EUW-29*	1964	1972
IN-47	1967	1978
EU-29A*	1972	?
IN-3147	1977	1982

Decade Capacitance Boxes

Model:	From:	To:
DC-1	1952	1961
IN-21	1961	1976
IN-27	1977	1980
IN-3127	1980	?

* Part of the factory wired Malmstadt-Enke Instrumentation Lab by Heath.

Table 1: Heathkit Capacitance Boxes & Approximate Production Years

Figure 1: Heathkit CS-1 Condenser Substitution Box set for 0.01 μF

"condenser" more accurately describing a thermodynamic device. Many older radios used paper dielectric capacitors (or a similar construction) in non-critical parts of circuits for capacitances from 0.001 μF up to 0.5 μF and beyond. These capacitors can be recognized as they are often sealed with wax and the wax tends to become soft and bubble or drip with heat and age. (Figure 3). Capacitors can fail open or shorted, develop series resistance, develop leakage or change value. Shorted capacitors are usually easy to diagnose, but excessive leakage, which is common with older capaci-

100 pF [1]	(0.00010 µF)	0.010 µF
220 pF [1]	(0.00022 µF)	0.015 µF
470 pF [1]	(0.00047 µF)	0.022 µF
1,000 pF	(0.00100 µF)	0.033 µF
1,500 pF	(0.00150 µF)	0.047 µF
2,200 pF	(0.00220 µF)	0.068 µF
3,300 pF	(0.00330 µF)	0.100 µF
4,700 pF	(0.00470 µF)	0.150 µF [2]
6,800 pF	(0.00680 µF)	0.220 µF [2]

Capacitors rated: 600 VDC 10% except:
[1] 500 VDC 5% [2] 400 VDC 10%

Table 2: Capacitor Values for the CS-1, IN-22, IN-47, IN-3147 EUW-29 & EU-9A Capacitor Substitution Boxes

tors, as well as the other failure modes are harder to diagnose. Thus a substitution box for capacitors is very handy for troubleshooting.

The Heathkit CS-1 Condenser Substitution Box: The Heathkit CS-1 (shown in figure 1) is one of numerous devices that allows selection of a capacitance for testing or lab experimenting. Table 1 lists Heathkit capacitor substitution boxes and decade capacitance boxes.

The six capacitance substitution box kits made by Heathkit, including the EU series, are all electrically identical to the CS-1. The CS-1 contains eighteen 400, 500 or 600 volt 5% or 10% tolerance capacitors, an 18-position rotary switch and two binding posts. The eighteen capacitors cover 100 pF to 0.22 µF. Table 2 shows the actual values, voltages and tolerances. The three lowest value capacitors are silver mica, and the remaining are axial tubular molded plastic types. Figure 2 shows the CS-1 insides.

The binding posts on the CS-1 are red and black indicating polarization. While the capacitors are not really polarized, many tubular capacitors need to be installed in the circuit in the proper direction for best performance. This is due to the construction of those tubular capacitors; they are assembled such that one side of

Figure 2: Heathkit CS-1 Condenser Substitution Box Interior

the capacitor is is electrically connected to the foil just under the outside insulation of the capacitor. This lead is often marked on the capacitor by a black line signifying the "outside foil". The outside of the capacitor is more susceptible to noise pickup and should be the side connected to ground (regardless of polarity) when one side of the capacitor is grounded. If neither side is grounded the "outer foil" lead should be connected to the lower impedance side of the circuit. For instance when the capacitor couples the plate of one stage to the grid of the next the this lead should go to the lower impedance plate circuit. The black binding post signifies the "outside foil" lead.

The CS-1 mounts in a black bakelite box that measures 6" L x 3" W x 2" H. All the compo-

nents mount on the aluminum face plate. Two paint schemes were used during the manufacture of the CS-1. The early model is finished in a light beige with red lettering, similar to other early Heathkit test equipment. The later model is shown in Figure 1; it is finished in dark grey with white lettering, similar to the style of the 60's line of test equipment.

The CS-1 Capacitance Substitution Box sold for $5.50 in 1956. This kit and its resistor companion, the RS-1 were basic kits and were usually only listed in the "Full" line Heathkit catalogs.

Using the Heathkit CS-1:

The most effective way to use the CS-1 is to unsolder or clip one lead of the capacitor you want to test and then clip in the substitution box in its place and select the desired capacitance. Recently I had an old (circa 1947) receiver that had audio problems. The coupling capacitor between the first and second audio stage was clipped and the replaced by the CS-1 set to the same capacitance. The audio immediately improved, but was still distorted. The capacitor was removed and tested (on a Heathkit IT-11 - Heathkit of the Month #2). It had very high leakage which was upsetting the bias on the last audio stage. The grid coupling capacitor for the first audio was subsequently tested with the same result, cleaning up the audio problem. The two capacitors tested so badly that all the paper capacitors in the radio were replaced. Subsequent testing revealed that only two of the twenty-five paper capacitors passed the leakage test and both of those showed a high series resistance.

Figure 3 shows two old capacitors from the NC-173 receiver and their modern replacements - all manufactured by Cornell Dubilier. The top two are older 0.01 µF and 0.05 µF 600 VDC MD series paper and wax capacitors. The bottom two capacitors 0.01 µF and 0.047 µF at 630 VDC Type 150 metallized polyester. The new capacitors take up about 1/4 the chassis area and 1/8 the volume.

Figure 3: Old and new style tubular capacitors (see text).

The Heathkit Decade Capacitor Boxes:

For laboratory use or more critical capacitor substitution, Heathkit made four models of decade capacitor boxes, all electrically similar. They cover 100 µµF (pF) to 0.111 µF in 100 µµF (pF) steps. The box has three ten-position rotary switches. The first switch selects 0 to 1,000 pF in 100 pF steps. The middle switch selects 0 to 0.01 µF in 0.001 µF (1,000 pF) steps, and the last switch selects 0 to 0.1 µF in 0.01 µF (10,000 pF) steps. The three circuits are in parallel so their values sum. Each switch uses four capacitors in a 1, 2, 3, 4 sequence that are selected by their switch to create the full decade. The capacitor tolerances and types used by Heathkit vary by model. Figure 4 shows the IN-3127. Figure 5 shows its schematic which is typical of all four models.

Summary:
This month a handy but simple piece of test equipment was covered along with its Heathkit derivatives. It is one of those pieces of test equipment that is infrequently used but very useful when needed.

It's time to look in the closet and ham shack and see what will be discussed next month. If you have a suggestion for a kit to be discussed feel free to email me. Uh oh, next month is April!

73, from AF6C

Figure 4: Heathkit Decade Capacitor Box Model IN-3127

Remember, if you are getting rid of any old Heathkit Manuals or Catalogs, please pass them along to me for my research.
Thanks, Bob - AF6C

*This article originally appeared in the **March 2012** issue of **RF**, the newsletter of the Orange County Amateur Radio Club - W6ZE.*

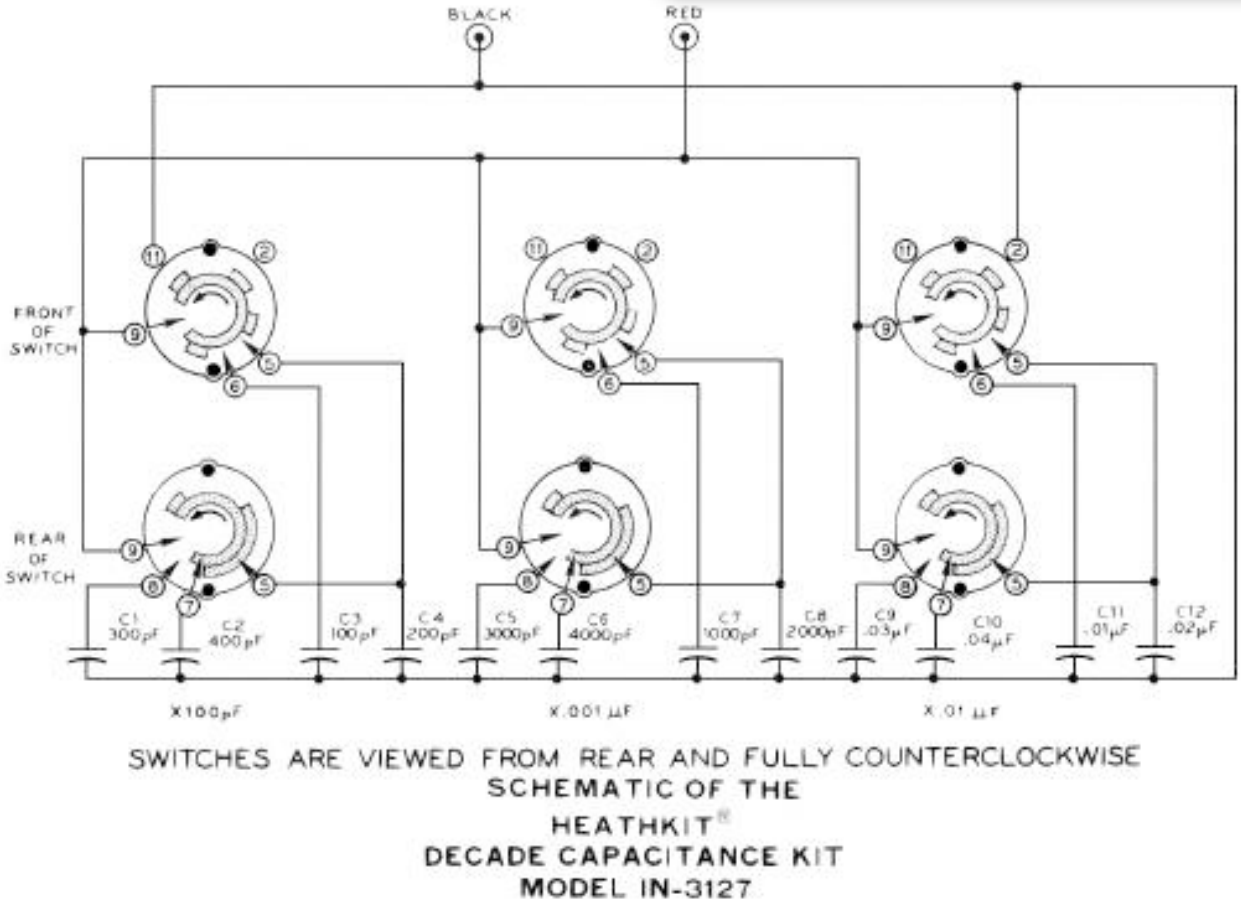

Figure 5: C1 – C4 are 500V 1% mica capacitors, C5 – C8 are 630V 1% polystyrene capacitors, C9 – C12 are 400V 5% mylar capacitors