Heathkit of the Month #121:
by Bob Eckweiler, AF6C

AMATEUR RADIO - SWL

Heathkit HD-10 Electronic Keyer

Introduction:

In very late 1965 or early 1966 Heathkit introduced the HD-10 Electronic Keyer. It is not listed in the main 1966 catalog, which is usually released late in the third-quarter of the prior year. The HD-10 sold for $39.95 throughout its lifetime and was discontinued in the second half of 1974. In 1975 Heathkit introduced its replacement, the HD-1410, which was introduced at $59.95.

The HD-10 Electronic Keyer:

The HD-10 (**Figure 1**) is all solid-state, using eleven transistors and seven diodes. It does not use any integrated circuits, which were just coming onto the market about that time. **Table I** lists the semiconductors. Sometime during production, Heath switched from the 2N407 to the 2N408 transistor [1].

The HD-10 is designed for use with transmitters using grid-block keying only, though there are modifications to allow positive voltage keying [2]. The HW-16, SB-110, SB-400 and DX-60A radios Heathkit was selling at the time, all use grid-block keying.

Here is a link to the index of Heathkit of the Month (HotM) articles:
http://www.w6ze.org/Heathkit/Heathkit_Index.html

1. Notes begin on page XX

Figure 1: My recently acquired HD-10 Electronic Keyer.

The HD-10 has a built-in paddle. It is not iambic, but it may be used either as an automatic keyer, where both dits and dahs [3] are created electronically, or where dits are automatic and the dahs are manual, similar to using a Vibroplex bug. The paddle may be wired for right or left handed people. Switching between them requires heating up the soldering iron and swapping a couple of internal wires as well as reversing the knobs on the keying paddle.

While primarily designed to run off 115 vac line voltage, the HD-10 can be run from batteries. Either a 45 V dry cell battery with a

HEATHKIT HD-10 SEMICONDUCTORS

Qty	Type	Heath #	Description
5	1N191	56-26	Ge Crystal Diode
2	CER100	57-29	Si Rectifier Diode
OR	1N4002	57-65	Si Rectifier Diode
1	2N398A	417-43	Ge PNP HV Transistor
7	2N407	417-28	Ge PNP Transistor
OR	2N408	417-18	Ge PNP Transistor
3	2N2712	417-67	Si NPN Transistor

Ge - Germanium Technology.

Si - Silicon Technology

TABLE I

22½ V tap (Burgess 5308, RCA VS-112, etc.) or two 22½ V dry cell batteries. Unfortunately these batteries have become expensive and not readily available in today's marketplace. In the manual, a scheme is given to power the HD-10 from 230 vac line voltage by installing a 0.068 µfd 600 volt capacitor in series with one lead of the power line cord [4].

The builder has a choice of two speed ranges depending upon which components are installed during assembly. Either 10 to 20 WPM or 15 to 60 WPM can be wired with the components supplied. [5]

The HD-10 Controls & Connections:

The HD 10 measures 3¾" W. 4¼" H x 10½"D with a sloping top panel. On the sloping panel, at the top, is a 2.6" speaker. Below it are two potentiometers, side by side. The left potentiometer sets the speed and the right one sets the volume. The speed potentiometer is a dual-clutched potentiometer; the inner potentiometer moves with the outer one but can be adjusted separately with a screwdriver through a hole in the top of the knob. This adjustment allows setting the dot-to-space ratio. Below the potentiometers is a neon pilot light indicating the keyer is powered. The pilot light remains off when operating from batteries. Below the pilot lamp is a three-position slide switch. **OFF** is to the left, the second position is **OP**e**R**ate and the third is **HOLD**. HOLD closes the keying-line for the purpose of tuning up or making other observations or adjustments.

The keying paddle extends from the front of the unit, and on the back (**Figure 2**) is an eight screw terminal strip. The two mounting studs hold knurled nuts for grounding. The terminal strip provides connection for the keying-line, battery connections, external paddle, and more. Also on the back is a ¼" phone jack for earphones, and a grommet for the two-conductor line cord to exit.

The HD-10 Paddle:

The paddle mechanism mounts on a heavy ballast plate. Its weight, along with the steel chassis, and large rubber feet, keep the keyer from moving on the desk when sending code. The key lever (arm) uses a spring hinge mounted to a switch bracket bolted to the

Figure 2: Rear panel of the HD-10 Keyer showing the eight screw terminal strip. The two thumb - nuts on the mounting studs are grounds. Also shown are the phones jack and line cord exit.

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ballast plate. Two leaf-springs and a shoulder spacer keep the key lever centered when in the neutral position. Switching is done by two microswitches, one activated when the key lever is moved to the left and the other when it is moved to the right. The HD-10 manual spends three pages on how to align the keyer arm and switches. Still when aligned correctly the paddle must move slightly less than 3/16" in either direction when sending. Neither of two reviews of the HD-10 [6] commented on this, but one wrote: *The built-in paddle is simple and ingenious and more than adequate for keyer beginners. Once you've become skillful, you'll probably want to switch to a paddle that has more precise action and is easily adjusted. Thinking ahead, Heath has provided for attaching an external paddle to the rear panel.*

HD-10 Assembly:

The HD-10 could be called a "two-evening kit", a guide later used in many Heathkit ads. An 'evening' probably assumes three to four hours, as a guess. Assembly is simplified by the use of a printed circuit board that holds a large majority of the components including the two transformers. The eleven transistors are socketed [7]; they aren't subject to soldering heat. **Figure 3** shows the HD-10

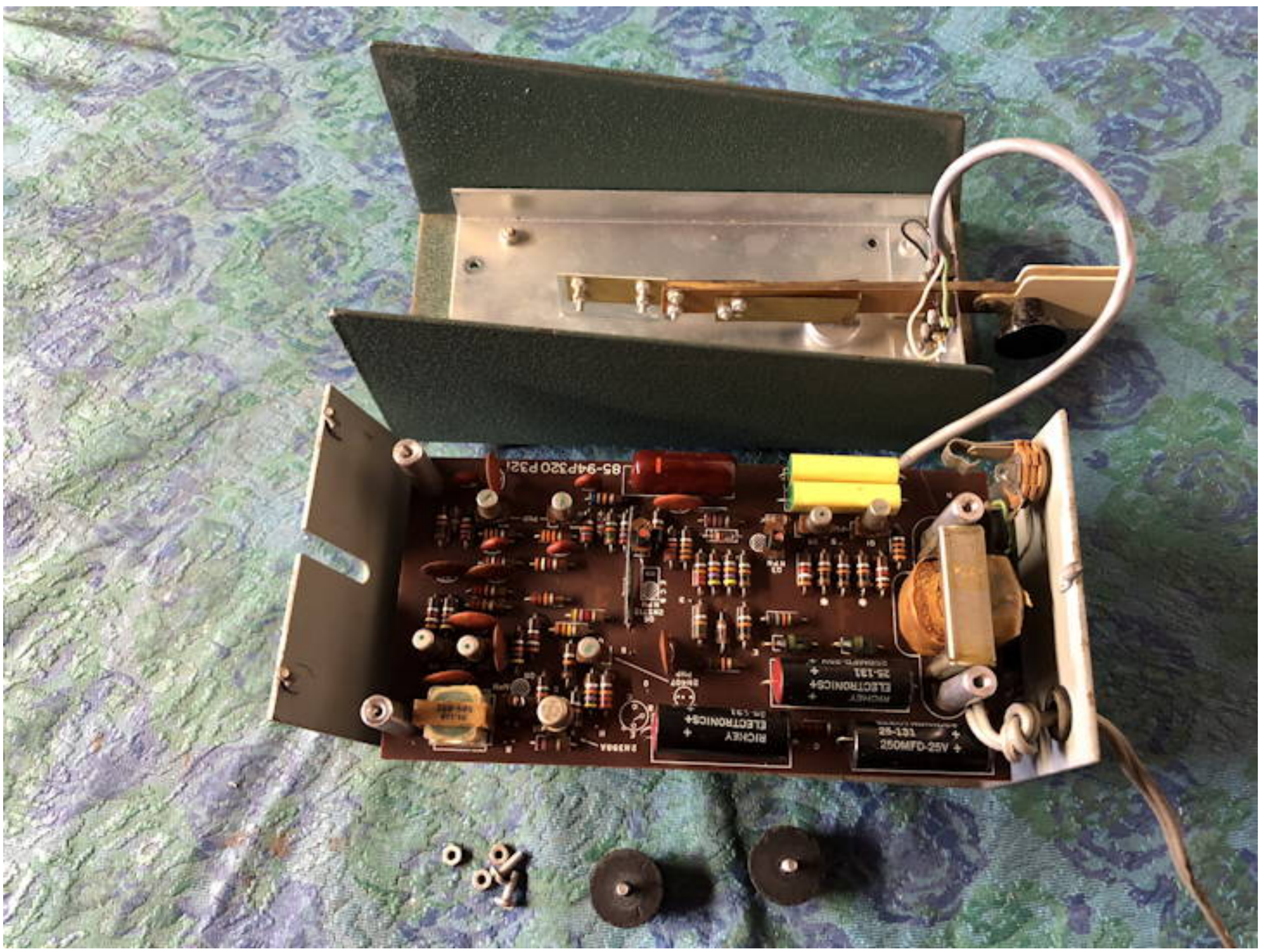

Figure 3: Internal view of the HD-10 with the cover removed showing the circuit board and keying mechanism. The power transformer is to the right and the smaller audio transformer is at the lower left.

cabinet open, revealing the circuit board as well as the keying mechanism. This keyer, being early production, uses the 2N407 transistors.

Final assembly of the HD-10 is a bit convoluted. The manual instructions, however, make it very clear how to proceed. The three assemblies (cabinet top assembly, circuit board assembly and cabinet bottom assembly) are laid on their left sides viewed from the front. The interconnecting cables, already attached, are dressed properly and then the circuit board is attached to the cabinet bottom assembly using 6-32 screws: ⅜" in the rear and ⅝" (through) feet in the front (See **Figure 4A** - Pictorial 11). The cabinet sections are then joined. Three 6-32 threaded studs are on the cabinet top. One is mated first with a notch at the rear cabinet bottom. The cabinet top is then lowered in an arc so the two front studs go into holes at the front of the cabinet bottom. The studs are then secured using #6 lockwashers and nuts (See **Figure 4B** - Pictorial 12).

If the cabinet needs to be reopened, do not follow the above procedure in reverse. The circuit board can easily be damaged by the phone jack, and wires can be pulled loose. In the manual Heath dedicates a short paragraph

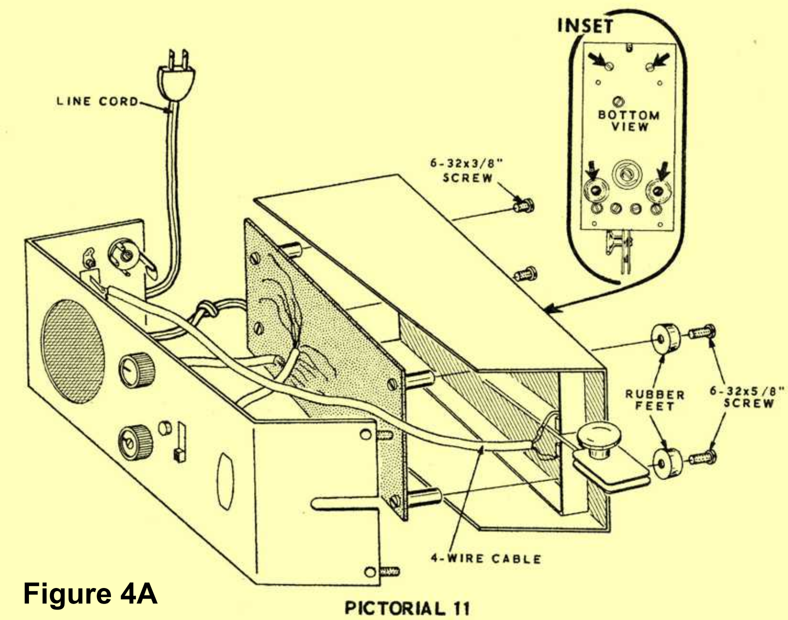

Figure 4A

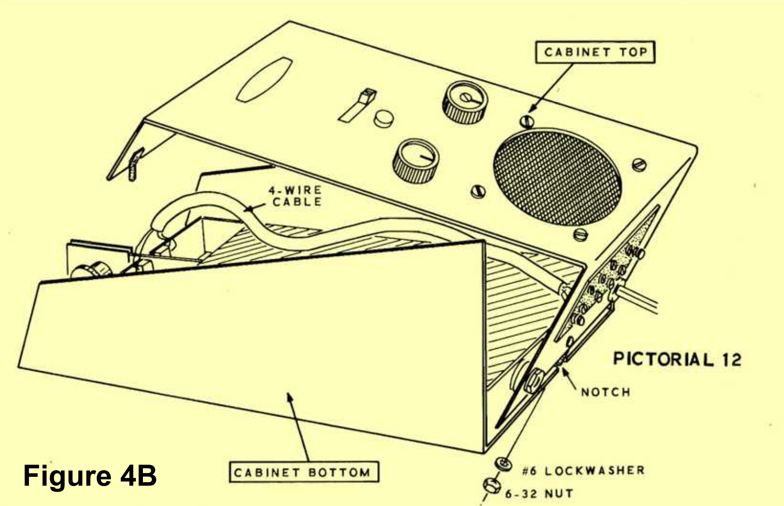

Figure 4B

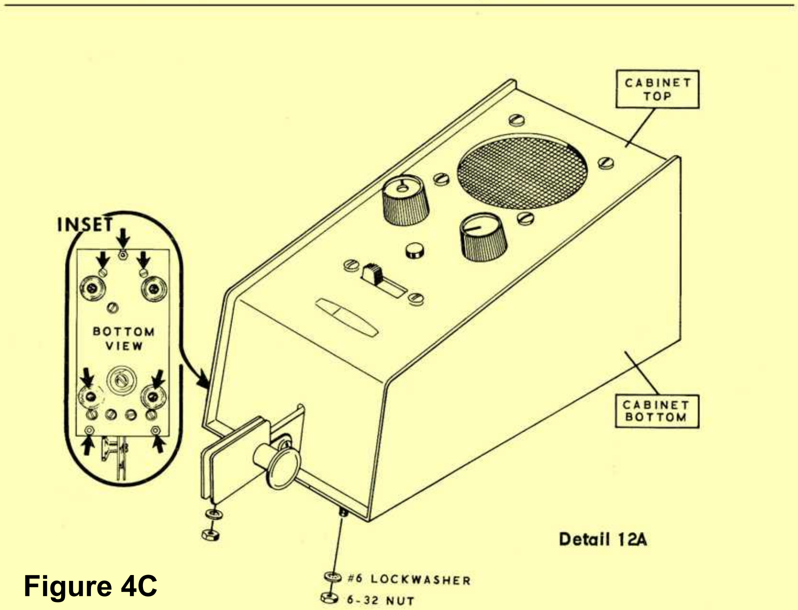

Figure 4C

Figure 4: Assembly and reopening of the HD-10 cabinet. These three illustrations are from the HD-10 manual [595-307]. **A:** shows how to align the assemblies before attaching the circuit board. **B:** shows how to joint the two cabinet assemblies. And **C:** shows how to properly reopen the cabinet.

HEATHKIT HD-10 SPECIFICATIONS

KEYING:	
Speed:	15 to over 60 WPM code group. (Alternate connection for 10 to 20 WPM code group.)
Keying Output:	Keyed line to chassis ground.
Voltage Polarity:	Negative to ground only.
Maximum Open-Circuit or Spike Voltage:	105 volts.
Key-Closed Voltage:	0.2 volts maximum.
Key Closed Current:	35 milliamperes maximum.
GENERAL:	
Audio:	Internal speaker or high impedance headphone jack.
Transistor Complement:	7 2N407/2N408 PNP Germanium 3 2N2712 NPN Silicon 1 2N394A PNP Germanium.
Controls:	Off-operate-hold switch. Speed control. Dot-to-Space ratio control. Volume Control
Rear Panel Connections:	Keyed line. Receiver Audio. Battery +45 volts. Battery +22 ½ volts. Hand key. Dash arm. Dash. Dot.
Power Requirements:	AC operation: 105 - 125 volts AC, 50 / 60 cps. Battery operation: 45 volts with 22 ½ volts tap; 14 milliamperes.
Dimensions:	3 ¾” wide x 4 ¼” high x 10 ½” deep.
	5 lbs.

TABLE II

on how to properly re-open the cabinet:

(√) *To open the cabinet, remove the nuts and screws indicated by the arrows in the inset drawing of Detail 12A. Then lift the cabinet top and circuit board out of the cabinet bottom.*

Detail 12A and the mentioned inset are shown in **Figure 4C**.

HD-10 Specifications & Circuit:

Table II lists the HD-10 specifications, from the manual. **Table III** lists the timing values for international Morse code.

Figure 5 is a block diagram of the HD-10 from the manual and **Figure 7** is the schematic. Often the circuit descriptions supplied in the Heathkit manuals are basic and lack a lot of detail. In the HotM articles an attempt is made to provide a more de-

Morse Code Timing Basics

The timing of an international Morse code sentence is based on the “T-Unit” which is the length of a dit in milliseconds (mS). Here are the defined lengths for other parts of the International Morse code:

Dit length:	1T (by definition)
Dah length:	3T
Intra-character space [a]:	1T
Inter-character space [b]:	3T
Inter-word space:	7T

[a] The space between dits and dahs within a character.
[b] The gap between the characters of a word.

Here are values of T for some common speeds:

5 WPM	240.0 mS.
10 WPM	120.0 mS.
13 WPM	92.3 mS.
18 WPM	66.7 mS.
20 WPM	60.0 mS.

Caution: These ’T’ values are only good for determining WPM. A second code speed exists, ‘Code Groups Per Minute’ which have slightly different values for ’T’.

TABLE III

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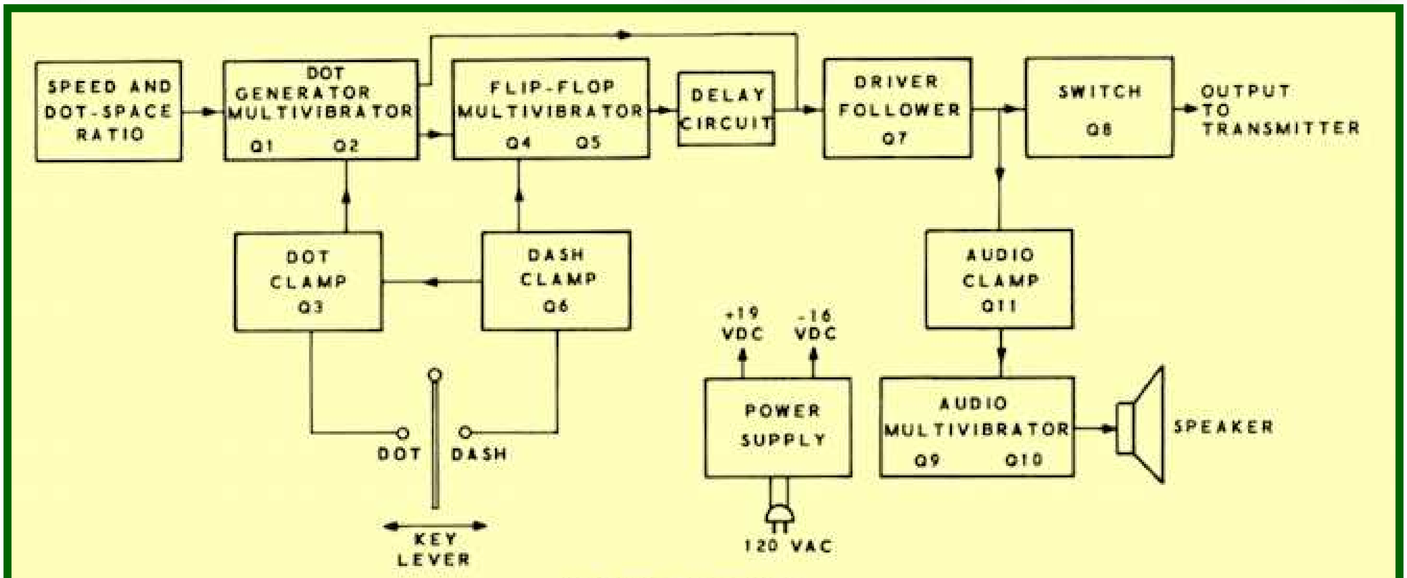


BLOCK DIAGRAM

tailed description. However, the circuit description of the HD-10 is quite detailed, taking up six pages. And it would be redundant to go into too much detail. Thus a shortened description of the circuit follows:

The power supply is simply two half-wave rectifiers and filters producing +19 volts and –16 volts, both unregulated.

Three similar flip-flop circuits, each using two 2N407 or 2N408 transistors, and each controlled by a clamp transistor, make up a majority of the circuitry. Two of the flip-flops, the dot generator and the audio generator, are wired as multivibrators. With the key lever centered, clamp transistors Q3, Q6 and Q11 are conducting and hold the dot multivibrator, the dash flip-flop and the audio multivibrator in a defined initial state.

Dot Generation:
In the clamped state Q1 is conducting and Q2 is off. When the key lever is moved to the dot side S1 closes, turning off the clamp Q3. Q1 and Q2 immediately flip state, with the collector of Q1 going high, turning on Q7 and Q8 through R79. Q7 is wired as an emitter follower, and turns on Q8, the keying-line. After a period of time set by C10, C20 R11, R12, R22 and the speed and dot-space ratio ganged controls, the dot generator will again switch states turning off Q7 and Q8. Should the lever remain in the dot position, the dot multivibrator will continue to switch on and off at the same period of time producing a string of dots at the output. When the lever is moved to center, S1 opens, but the collector of Q1 is also connected to the base of Q3 through R30, so the Q3 clamp won't start to conduct until the dot and following space are completed.

Dash Generation:
Q4 and Q5 make up the dash flip-flop. this flip-flop will remain in whatever state it is in (when not clamped) until a positive going pulse is applied to the base of the transistor that is conducting. The pulse will cause the flip flop to change state. In the clamped state Q4 is held off and Q5 is conducting due to the clamp transistor Q6. When the key lever is moved to the dash side S2 closes turning off the clamp Q6. At the same time, due to diode D1, it also turns off clamp Q3, turning

on the dot multivibrator. When the dot multivibrator turns on, Q2 immediately switches on. The collector voltage goes from -16 to near zero volts. This is coupled through C41 and D40, producing a pulse at the base of Q4. It is also coupled through C51 and diode D50 producing a pulse at the base of Q5. The pulse causes the flip flop to change state. Q4 is now conducting and Q5 is off. When the dot generator completes the dot and following space, Q2 again switches on causing a pulse to the base of Q4 causing the flip-flop to again change state. When Q5 is off, Q7 is on. Thus Q7 is held on by both the dot multivibrator and flip-flop for the first ⅓ of the dash, by just the flip-flop for the second ⅓ of the dash and by the second dot of the dot multivibrator for the last ⅓ of the dash. R70, R71, R72, C70 and C71 delay the arrival of the dash to Q7 slightly to overlap and prevent any glitch that may occur when Q5 is turning on and Q1 is turning off.

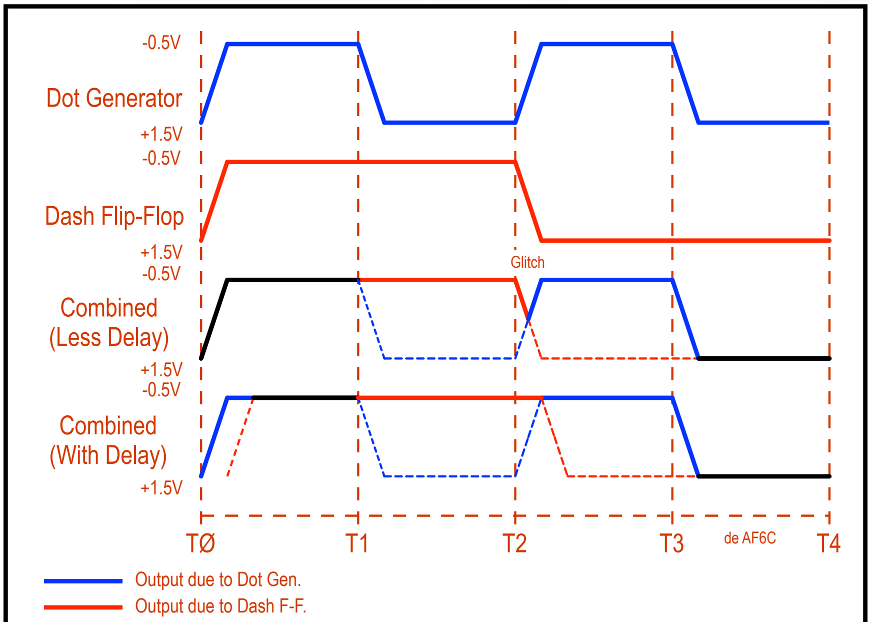
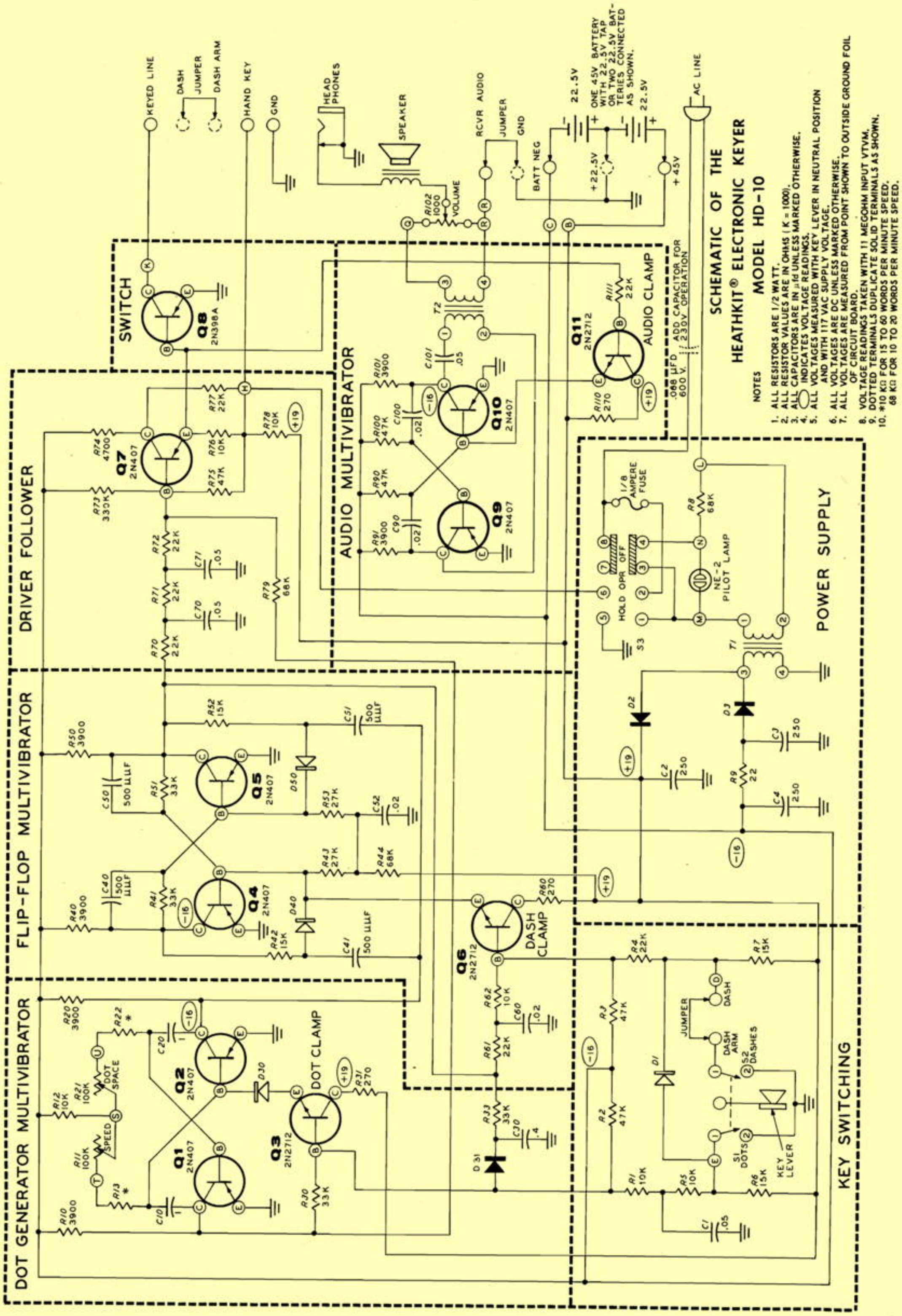


Figure 6: (See Text).

Figure 6 demonstrates sending a dash. The horizontal axis is time and the distance between the vertical lines represents the length of a dot. A dash is considered to be the length of three dots and the space between dot generator and dash flip-flop signals mix at the base of Q7 to form a dash. The slope of the vertical lines have been exaggerated to better show the glitch that is created without the delay; in reality they are much steeper. The top trace is the dot generator signal to Q7; if sent alone it would produce two dots. The second trace is the output of the dash flip-flop sent to Q7, If sent alone it would send just two-thirds of a dash. The third trace is what happens when they both are sent to Q7. You get a full dash; but there is a glitch that occurs when the flip-flop and dot generator swap levels. The fourth trace shows how delaying the arrival of the flip-flop signal by just a few microseconds resolves the glitch problem without affecting the dash shape.

Driver Follower and Switch:

Q7 is normally biased into cut-off by resistors R73 to R76 and R78. The emitter of Q7 is at a positive 1.5 volts and is directly connected to Q8 Keeping it cutoff. Q8 gets its negative collector voltage externally from the device it is keying. The emitter of Q8 is grounded. When Q8 turns on it grounds the keying-line causing the transmitter to key. If an external hand key is attached to the HD-10 and closed, or if the function switch is set to HOLD, the junction of R75, R76, R77 and R78 is grounded, changing the bias on Q7 and causing it to conduct, turning on Q8. When Q1 turns off a negative 16 volts is fed through R79 to the base of Q7 turning it and Q8 on. Likewise, when Q5 turns off, a negative 16 volts is fed through the delay circuit


SCHEMATIC OF THE
HEATHKIT® ELECTRONIC KEYER
MODEL HD-10
SWITCH
DRIVER FOLLOWER
AUDIO MULTIVIBRATOR
AUDIO CLAMP
FLIP-FLOP MULTIVIBRATOR
DOT GENERATOR MULTIVIBRATOR
DOT CLAMP
DASH CLAMP
POWER SUPPLY
KEY SWITCHING
KEYED LINE
HAND KEY
GND
HEAD PHONES
SPEAKER
RCVR AUDIO
AC LINE
ONE 45V BATTERY WITH 22.5V TAP OR TWO 22.5V BATTERIES CONNECTED AS SHOWN.
NOTES
1. ALL RESISTORS ARE 1/2 WATT.
2. ALL RESISTOR VALUES ARE IN OHMS (K = 1000).
3. ALL CAPACITORS ARE IN µfd UNLESS MARKED OTHERWISE.
4. INDICATES VOLTAGE READINGS.
5. ALL VOLTAGES MEASURED WITH KEY LEVER IN NEUTRAL POSITION AND WITH 117 VAC SUPPLY VOLTAGE.
6. ALL VOLTAGES ARE DC UNLESS MARKED OTHERWISE.
7. ALL VOLTAGES ARE MEASURED FROM POINT SHOWN TO OUTSIDE GROUND FOIL OF CIRCUIT BOARD.
8. VOLTAGE READINGS TAKEN WITH 11 MEGOHM INPUT VTVM.
9. DOTTED TERMINALS DUPLICATE SOLID TERMINALS AS SHOWN.
10. *10 KΩ FOR 15 TO 60 WORDS PER MINUTE SPEED. 68 KΩ FOR 10 TO 20 WORDS PER MINUTE SPEED.

to the base of Q7 turning it and Q8 on.

Audio Monitor:
Q9 and Q10 form the third flip-flop circuit; a multivibrator operating around 750 cps. Q11 is a clamp that keeps Q10 cutoff. When Q7 conducts its output is fed to Q11 starting the multivibrator. The resulting audio tone is coupled through T2 and the volume control to the speaker and phone jack. If earphones are being used, the audio from the receiver can be connected to the **RCVR AUDIO** input of the HD-10, so both can be heard in the earphones.

The HD-10 shown was purchased at a garage sale right before the pandemic. It sat until a month ago when it was put on the bench and found working with one minor problem; the dot switch would often stick. It was put aside as other keyers are in use in the shack.

The Pickering K-1 Micro-Ultimatic Keyer:
In 1966 Tom Pickering - W1CFW published an article called the “Micro-Ultimatic[8], a digital iambic keyer using Fairchild RTL logic integrated circuits. Back then I decided to build one, but instead of using 15[9] epoxy pill style 8-lead ICs I used 7 Motorola 700 series 14 pin DIP style RTL ICs (2 ea. MC724P quad, two input NAND gates; 3 ea. MC790P dual JK flip-flops; and 2 ea. MC792P triple, three input NAND gates.)

Tom Pickering later formed the Pickering Radio Company, selling an updated Micro-Ultimate key as the Pickering Radio Co. K-1, as well as code learning material and code practice tapes (**Figure 8**).

The Heathkit HD-1410 Keyer:
Heathkit missed the digital IC age with the HD-10 by a matter of months. For about 10 years, while the digital IC era expanded, Heathkit continued to profitably sell the HD-10. Less than year after the HD-10 was discontinued, Heath introduced the digital HD-1410 Keyer; a keyer based on the TTL digital logic family. Perhaps the HD-1410 will be the topic of an HotM article in the near future?

Summary:
Heathkit introduced the HD-10 using discrete components. Even though the digital IC introduction quickly followed and, even though the keyer paddle was not ideal, Heath still sold a lot of these keyers. Reviews were good, You can often find the HD-10 at electronic swap-meets and garage sales.

I’m left-handed, and I’ve occasionally had to make a CW QSO at a friend’s house using a bug or electronic keyer by turning it around and working it from the back. I’ve always wondered why there wasn’t a simple switch on all keyers to change the key configuration. A simple DPDT slide switch is all that is re-

Figure 8: One of a set of three reel-to-reel code practice tapes sold by The Pickering Radio Company in the late 1960s.

quired. Some years back the group of Orange County (CA) amateur radio clubs sponsored a ham radio booth at the county fair. I forget the model of the keyer in use, but I did finally find how to switch it from right to left hand operation. One needed to go down numerous menus to do it. But there was no display so, without the manual, one would likely not succeed. Yes, I did set it back after I was finished – but I needed to refer to the manual again to do it!

HD-10 Changes Over Its Production Run:

Gerhard - DF1DA and Steve - N8FH, provided me different PDF versions of the HD-10 manual; 595-703 (3/25/1966) and 595-703-5 (undated - but close to the end of production). Cross-referencing the two parts lists showed a few changes. The OFF-OPR-HOLD switch changed from P/N 60-10 to P/N 60-22, though the new switch is physically close; the speaker P/N changed from 401-84 to 401-118, both 2.6" dia. and 100 Ω impedance, but with a significant change in cost; the neon pilot light changed from a sealed assembly (412-13) to an NE-2E (412-36) and a (413-10) red lens; the two rectifier diodes changed from a CER100 (57-29) to a 1N4002 (57-65); and, as mentioned earlier, the 2N407 transistors were changed to 2N408. One other change occurred; the 3 four-pin transistor sockets (434-101) were removed from the parts list and the 3 silicon 2N2712 transistors were soldered directly to the circuit board.

73, from AF6C

Notes:

1. The 2N407 and 2N408 are identical electrically; they differ in style of case. Lead layout remains the same.
2. Positive Keying modifications (Note these mods are for the newer transistorized radios that normally key +12V to ground. They will not work on high voltage / current needed for cathode keying):

   QST Jul. 1978 (Hints and Kinks) p 34: *Positive Key Line and the HD-10 Keyer*". Norman Bradshaw - W8EEF.

   Ham Radio Nov. 1978 (The Ham Notebook) p 88: *Positive lead keying for the HD-10 Keyer*. Richard Jasper, W4VAF.
3. Dah is the sound made by a dash. Di is the sound made by a dot except when it ends the character; then it is a Dit. Thus the letter 'P' is Di Dah Dah Dit.
4. I'd recommend, if you decide to try this, you make sure the capacitor is in series with the hot lead. and house the capacitor in a small box with good strain relief.
5. For 10 - 20 WPM – R13 and R22 are 68 KΩ
For 15 - 60 WPM – R13 and R22 are 10 KΩ
6. Reviews of the HD-10 appeared in:

   73 Magazine Mar. 1966 p 6: *The HD-10 Heathkit's New Electronic Keyer* – Mort Waters - W2JDL

   QST Jan. 1967 (Recent Equipment) p 45: *Heath HD-10 Keyer* – W1CER
7. In later production runs, the germanium transistors are socketed and the 3 silicon 2N2712 are soldered on the printed circuit board.
8. **73 Magazine** Jun. 1966 p 50: *The Micro Ultimate - Integrated circuits in a high-performance electronic keyer* – Tom Pickering - W1CFW.
9. In the original article 13 Fairchild epoxy packaged 8-lead ICs were used. The circuit was later improved resulting in replacing four dual-NAND gates (two per package) with four triple NAND gates (one per package). The Motorola DIP package contains four dual NAND gates (MC-724) and three triple NAND gates (MC792). The two spare triple NAND gates were used elsewhere.

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

*This article is copyright 2024, and originally appeared in the March 2024 issue of '**RF**', the newsletter of the Orange County Amateur Radio Club - W6ZE.*

Thanks - AF6C